

Assessment of the Adequacy of the Appendix F
Quality Assurance Procedures for Maintaining
CEMS (Continuous Emission Monitoring Systems)
Data Accuracy (Status Report No. 1)

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Prepared for

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ASSESSMENT OF THE ADEQUACY OF THE APPENDIX F QUALITY ASSURANCE
PROCEDURES FOR MAINTAINING CEMS DATA ACCURACY (

STATUS REPORT #1

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16. ABSTRACT This report summarizes the first year's audit results of Continuous Emission Monitoring Systems (CEMS) installed at scrubber-equipped power plants. The audits were conducted to support a draft quality assurance appendix for 40 CFR 60 entitled "Quality Assurance Procedures for Gas CEMS Used for Compliance". The procedures call for a quality performance audit of the CEMS using certified cylinder gas or reference method tests. Audit data have been collected for sulfur dioxide, nitrogen oxides, oxygen and carbon dioxide. EDC, Contraves, Lear Seigler and DuPont CEMS have been audited, with the results indicating the need for frequent audits with effective corrective action to be taken when excessive inaccuracies are measured.		
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1. INTRODUCTION

The U. S. EPA, Quality Assurance Division, is currently involved in the development of "Appendix F - Quality Assurance Procedures, Procedure 1 - Quality Assurance Requirements for Gas Continuous Emission Monitoring Systems (CEMS) for Compliance" for future inclusion in 40 CFR 60. The most recent draft of Appendix F, Procedure 1, requires the source owner or operator:

- (1) to develop and implement a quality control program that includes written procedures for key CEMS operations,
- (2) to calculate monthly data precision for each CEMS monitoring channel from results of daily span checks, and
- (3) to determine quarterly the accuracy of each CEMS. Two methods are provided in Procedure 1: a cylinder gas audit (CGA) for CEMSs capable of accepting calibration gases, and a relative accuracy audit (RAA) for all CEMSs.

To evaluate the adequacy and effectiveness of the specific CEMS data accuracy assessment procedures included in Procedure 1, a field performance audit program is currently being conducted. The program involves periodic testing of a number of operational CEMS installed at the outlet of FGD equipped fossil fuel-fired steam generators. This report summarizes preliminary conclusions, recommendations, and results of the first phase of this program. Subsequent reports will include additional test results and information obtained from the second phase of the audit program.

The specific aspects of the Procedure 1 CEMS data accuracy assessment procedures being evaluated are:

1. the appropriateness of the time interval between accuracy audits (i.e., quarterly audits) to ensure long-term, high quality CEMS data;
2. the use of a six-run instead of a nine-run system relative accuracy test;
3. the appropriateness of the relative accuracy audit (RAA) decision limit of $\leq 25\%$ for the six-run relative accuracy audits;
4. the necessity and effectiveness of adding individual pollutant and diluent monitoring channel relative accuracy determinations;
5. the adequacy of a one-time calibration gas injection procedure for the (cylinder gas audit (CGA) assessment instead of the five-time, nonconsecutive calibration gas injection procedure prescribed in the calibration error test requirements of Performance Specification 2, Appendix B, 40 CFR 60;
6. the necessity and effectiveness of including a third audit point at 20-30% of the monitor span value in the CGA procedure for pollutant monitors;
7. the appropriateness of the CGA decision limit of $\pm 10\%$; and

8. the relationship between the CGA and RAA results (i.e., do both procedures provide equivalent conclusions pertaining to CEMS data accuracy).

During the field auditing program, more extensive accuracy testing procedures than those of Procedure 1 were utilized to provide a basis from which to evaluate the adequacy and effectiveness of Procedure 1. Full calibration error determinations were performed to assess the CGA procedures. Complete relative accuracy determinations, as presented in Performance Specification 2, Appendix B, 40 CFR 60 and in the proposed Performance Specification 2, (January 26, 1981, Federal Register) were conducted to assess the RAA procedures. In addition, field audits were repeated periodically for most of the CEMS in this study to determine the appropriate frequency for conducting CEMS data accuracy assessments.

The CEMS performance audit program included four monitoring systems most widely used by the electric utility industry. These systems are manufactured by Lear Siegler, Inc. (SM810 SO₂/NO - CM50 O₂), Contraves-Goerz Corporation (GEM-1 SO₂/CO₂), Environmental Data Corporation (DIGI 1400 SO₂/CO₂), and DuPont Instruments (DuPont 460 SO₂ - Thermox O₂).

Attempts were made to perform quarterly audits. Although source representatives were informed well in advance of each audit, they indicated that no extraordinary actions were implemented before or during the auditing program to enhance the performance of the monitoring systems, and only the routine quality assurance (QA) program was maintained throughout this study. Only those CEMS where the source representatives indicated that the CEMS were functioning properly were audited; CEMSs experiencing difficulties were not audited until the source representatives indicated that the apparent problems had been resolved.

2. CONCLUSIONS AND RECOMMENDATIONS

This section presents the preliminary conclusions and recommendations for the first phase of the field audit program.

2.1 CONCLUSIONS

1. The six-run and $\leq 20\%$ limit RAA affords the same conclusion regarding CEMS data accuracy as the nine-run and $\leq 20\%$ limit relative accuracy test presented in the proposed Performance Specification 2 (Federal Register Vol. 46, No. 16, January 26, 1981).
2. The installed CEMSs display a high level of precision. Therefore, in almost all cases, the one-time calibration gas injection of the CGA procedure provided the same information as a complete calibration error determination (a five-time nonconsecutive calibration gas injection test).
3. A third audit point at 20 to 30% of the monitor span value (in addition to the two audit points prescribed in the CGA procedure) frequently provides checks of both calibration and linearity at the normal operating range of the monitor.
4. Insufficient testing has been performed to determine: (a) any relationships between the results of CGA and RAA, and (b) the appropriateness of the $\pm 10\%$ CGA decision limit.
5. The six-run RAA results demonstrate a need for conducting frequent audits to assess CEMS accuracy. It should be noted that exceedances of the 25% relative accuracy limit specified in Appendix F were observed for: (a) the Contraves-Goerz SO_2/CO_2 CEMS for two consecutive audits (12/81 and 3/82), and (b) a Leaf Siegler NO/O_2 CEMS for one audit (12/81). The quarterly frequency for RAA specified in Appendix F appears to be adequate.
6. The present absence of a requirement for conducting periodic accuracy audits of CEMS may result in effective corrective actions not being taken in a reasonable period of time, and thus, the acquisition of inaccurate data during consecutive emissions reporting periods.

2.2 RECOMMENDATIONS

2.2.1 Appendix F Accuracy Assessment Procedures

1. The six-run relative accuracy assessment is adequate and should not be changed to a nine-run relative accuracy assessment as prescribed in the proposed Performance Specification 2, Federal Register, Vol. 46, No. 16, January 26, 1981.
2. Appendix F should suggest (but not require) that the source operator conduct sufficient testing to determine the relative accuracy of each pollutant and diluent monitoring channel. The additional testing does not require additional personnel and does not significantly increase the time required to perform the RAA.
3. The CGA procedure (one-time calibration gas injection) should not be expanded to a five-time, nonconsecutive calibration gas injection test based upon the available test results.
4. The CGA procedure should be expanded to include a third audit point (20-30% of monitor span) for the pollutant monitoring channel of CEMS installed downstream of FGDs. The additional time and effort required to perform testing for the third audit point is minimal.

2.2.2 Test Program Methodology

The following are recommendations for the second phase of the CEM field audit program:

1. Only six-run tests should be conducted; nine-run relative accuracy tests should no longer be performed.
2. Channel system relative accuracy assessments should be continued.
3. Full calibration error determinations should be continued.
4. Three-point CGA assessments should be continued for pollutant monitors.
5. Additional extractive CEMS types should be investigated. A KVB monitoring system should be included to provide information on the Western Research SO₂ and Thermo Electron NO_x monitors (the current data base does not include any information on these monitors). Testing of this system will also provide additional information for evaluating the relationship between CGA and RAA results.

3. SUMMARY OF RESULTS

This section summarizes the preliminary results obtained from the CEMS field performance audits.

3.1 DATA ACCURACY AUDIT FREQUENCY

1. The six-run RAA results presented in Tables 1 - 5 demonstrate the need for conducting frequent audits. The quarterly accuracy audit specified in Appendix F to coincide with the quarterly submission of emissions monitoring data to the applicable control agency appear to be adequate.

It should be noted that in a letter to EPA dated September 8, 1982, the Contraves-Goerz Corporation expressed concern that the Contraves-Goerz CEMS installed at source "N" began experiencing operational difficulties during October 1981. Although Contraves service representatives replaced several components and restored the instrument to normal operation during November 1981, the results of RAA conducted in December 1981 (128%) and March 1982 (62%) greatly exceed the 25% RAA limit specified in Procedure 1. These results show that the corrective actions initiated by the CEMS operators and CEMS manufacturer were insufficient or ineffective, thereby resulting in the generation of inaccurate emissions data for a significant period of time following the corrective actions.

3.2 RELATIVE ACCURACY AUDIT PROCEDURE

1. All nine-run system and channel relative accuracy tests with relative accuracy values of $\leq 20\%$ also provided six-run system and channel relative accuracy values (the first six runs of the nine-run relative accuracy test) of $\leq 25\%$.
2. All nine-run system and channel relative accuracy tests having relative accuracy values in excess of 20% also provided six-run system and channel relative accuracy values in excess of 25%.
3. Most (86%) six-run relative accuracy determinations provided higher relative accuracy values than the nine-run relative accuracy determinations. The higher six-run relative accuracy values were due to an increase in the 95% confidence interval computation.

TABLE 1.

SIX-RUN RELATIVE ACCURACY AUDIT (RAA) RESULTS FOR
CEMS INSTALLED ON COAL-FIRED FGD EQUIPPED BOILER

Source "A"
DuPont 460 SO₂ - Thermox O₂ CEMS¹

Test ² Date	SO ₂ CHANNEL		O ₂ CHANNEL		SO ₂ /O ₂ SYSTEM	
	Effluent Concentration (ppm _d)	RA (%)	Effluent Concentration (%O _{2d})	RA (%)	Emission Level (lb/10 ⁶ Btu)	RA (%)
1/81	—	—	—	—	0.40	(-) 8.0
11/81	146	(+)13.0	12.2	(-)2.8	0.57	(+) 9.5
4/82	133	(+)23.2	9.4	(-)5.1	0.39	(+)19.7

¹SO₂ monitor range: 0 - 400 ppm SO₂; O₂ monitor range: 0 - 25% O₂.

²The test data for 01/81 were obtained from the initial monitoring system Performance Specification Test. All subsequent test results were obtained during the implementation of the Appendix F performance audit program.

Note: The "Effluent Concentration" values are the average Reference Method test result obtained during the six-run relative accuracy test. "Emission Levels" were computed using the procedures presented in Reference Method 19 from the Reference Method results and are expressed in units of lbs pollutant per million Btu.

The "+" or "-" in parentheses before the RA values indicate whether the monitor responses were greater than (+) or less than (-) the Reference Method test results. Channel relative accuracy determinations were performed in accordance with the procedures prescribed in Performance Specification 2, Appendix B, 40 CFR 60. System relative accuracy determinations were performed in accordance with the proposed revisions to Performance Specification 2 and 3 published in the Federal Register, January 26, 1981. For both the channel and system relative accuracy determinations, six runs were performed instead of nine runs.

TABLE 2.

SIX-RUN RELATIVE ACCURACY AUDIT (RAA) RESULTS FOR
CEMS INSTALLED ON COAL-FIRED FGD EQUIPPED BOILER

Source "P"
EDC DIGI Series 1400 SO₂/CO₂ CEMS¹

Test ² Date	SO ₂ CHANNEL		CO ₂ CHANNEL		SO ₂ /CO ₂ SYSTEM	
	Effluent Concentration (ppm _d)	RA (%)	Effluent Concentration (%CO _{2d})	RA (%)	Emission Level (lb/106 Btu)	RA (%)
7/80	—	(?)19.6	—	—	—	—
7/81	344	(+)11.3	9.7	(+)14.2	1.06	(-)12.3

¹SO₂ monitor range: 0 - 1000 ppm SO₂; CO₂ monitor range: 0 - 25% CO₂.

²The test data for 7/80 were obtained from the initial monitoring system Performance Specification Test. The test results for 7/81 were obtained during the implementation of the Appendix F performance audit program. No further audits were conducted because the source was unwilling to participate further in the testing program.

Note: The "Effluent Concentration" values are the average Reference Method test result obtained during the six-run relative accuracy test. "Emission Levels" were computed using the procedures presented in Reference Method 19 from the Reference Method results and are expressed in units of lbs pollutant per million Btu.

The "+" or "-" in parentheses before the RA values indicate whether the monitor responses were greater than (+) or less than (-) the Reference Method test results. Channel relative accuracy determinations were performed in accordance with the procedures prescribed in Performance Specification 2, Appendix B, 40 CFR 60. System relative accuracy determinations were performed in accordance with the proposed revisions to Performance Specification 2 and 3 published in the Federal Register, January 26, 1981. For both the channel and system relative accuracy determinations, six runs were performed instead of nine runs.

TABLE 3.

SIX-RUN RELATIVE ACCURACY AUDIT (RAA) RESULTS FOR
CEMS INSTALLED ON COAL-FIRED FGD EQUIPPED BOILER

Source "N"
Contraves Goerz GEM-1 SO₂/CO₂ CEMS¹

Test ² Date	SO ₂ CHANNEL		CO ₂ CHANNEL		SO ₂ /CO ₂ SYSTEM	
	Effluent Concentration (ppm _d)	RA (%)	Effluent Concentration (CO _{2d})	RA (%)	Emission Level (lb/10 ⁶ Btu)	RA (%)
9/80	396	(-) 8.0	12.9	(-) 18.1	0.92	(+) 18.8
7/81	188	(+) 13.0	13.0	(-) 4.5	0.43	(+) 12.3
12/81	170	(+) 80.3	11.2	(-) 36.3	0.45	(+) 128
3/82	225	(+) 52.0	11.9	(-) 9.2	0.57	(+) 61.8

¹SO₂ monitor range: 0 - 4000 ppm SO₂; CO₂ monitor range: 0 - 20% CO₂.

²The test data for 9/80 were obtained from the initial monitoring system Performance Specification Test. All subsequent test results were obtained during the implementation of the Appendix F performance audit program.

Note: The "Effluent Concentration" values are the average Reference Method test result obtained during the six-run relative accuracy test. "Emission Levels" were computed using the procedures presented in Reference Method 19 from the Reference Method results and are expressed in units of lbs pollutant per million Btu.

The "+" or "-" in parentheses before the RA values indicate whether the monitor responses were greater than (+) or less than (-) the Reference Method test results. Channel relative accuracy determinations were performed in accordance with the procedures prescribed in Performance Specification 2, Appendix B, 40 CFR 60. System relative accuracy determinations were performed in accordance with the proposed revisions to Performance Specification 2 and 3 published in the Federal Register, January 26, 1981. For both the channel and system relative accuracy determinations, six runs were performed instead of nine runs.

TABLE 4.

SIX-RUN RELATIVE ACCURACY AUDIT (RAA) RESULTS FOR
CEMS INSTALLED ON COAL-FIRED FGD EQUIPPED BOILER

Source "S1"
LSI SM810 SO₂/NO - CM50 O₂ CEMS¹

Test Date	SO ₂ CHANNEL		O ₂ CHANNEL		SO ₂ /O ₂ SYSTEM	
	Effluent Concentration (ppm _d)	RA (%)	Effluent Concentration (%O _{2d})	RA (%)	Emission Level (lb/10 ⁶ Btu)	RA (%)
6/80	347	(-)16.3	—	—	—	—
7/81	433	(+)15.1	7.6	(+) 7.6	1.10	(+) 18.6
12/81	476	(+) 7.2	7.3	(+) 4.2	1.18	(+) 8.9

Test Date	NO CHANNEL		O ₂ CHANNEL		NO/O ₂ SYSTEM	
	Effluent Concentration (ppm _d)	RA (%)	Effluent Concentration (%O _{2d})	RA (%)	Emission Level (lb/10 ⁶ Btu)	RA (%)
6/80	234	(+) 5.0	—	—	—	—
7/81	407	(-) 5.7	7.6	(+) 7.6	0.74	(-) 4.3
12/81	311	(+)20.5	7.3	(+) 4.2	0.56	(+) 22.9

¹SO₂ monitor range: 0 - 1500 ppm SO₂; NO monitor range: 0 - 1000 ppm NO; O₂ monitor range: 0 - 10% O₂ and 0 - 25% O₂.

²The test data for 6/80 were obtained from the initial monitoring system Performance Specification Test. All subsequent test results were obtained during the implementation of the Appendix F performance audit program.

Note: The "Effluent Concentration" values are the average Reference Method test result obtained during the six-run relative accuracy test. "Emission Levels" were computed using the procedures presented in Reference Method 19 from the Reference Method results and are expressed in units of lbs pollutant per million Btu.

The "+" or "-" in parentheses before the RA values indicate whether the monitor responses were greater than (+) or less than (-) the Reference Method test results. Channel relative accuracy determinations were performed in accordance with the procedures prescribed in Performance Specification 2, Appendix B, 40 CFR 60. System relative accuracy determinations were performed in accordance with the proposed revisions to Performance Specification 2 and 3 published in the Federal Register, January 26, 1981. For both the channel and system relative accuracy determinations, six runs were performed instead of nine runs.

TABLE 5.

SIX-RUN RELATIVE ACCURACY AUDIT (RAA) RESULTS FOR
CEMS INSTALLED ON COAL-FIRED FGD EQUIPPED BOILER

Source "S2"
LSI SM810 SO₂/NO - CM50 O₂ CEMS¹

Test ² Date	SO ₂ CHANNEL		O ₂ CHANNEL		SO ₂ /O ₂ SYSTEM	
	Effluent Concentration (ppm _d)	RA (%)	Effluent Concentration (%O _{2d})	RA (%)	Emission Level (lb/10 ⁶ Btu)	RA (%)
6/80	343	(-)16.8	—	—	—	—
5/81	453	(+)14.6	6.5	(+) 3.4	1.06	(+) 16.0
7/81	388	(+) 9.5	6.4	(+) 8.8	0.91	(+) 13.6
12/81	471	(-)10.1	7.2	(+)20.8	1.17	(+) 6.5
4/82	408	(+) 9.6	6.9	(+) 4.4	0.99	(+) 11.3

Test Date	NO CHANNEL		O ₂ CHANNEL		NO/O ₂ SYSTEM	
	Effluent Concentration (ppm _d)	RA (%)	Effluent Concentration (%O _{2d})	RA (%)	Emission Level (lb/10 ⁶ Btu)	RA (%)
6/80	232	(+)13.4	—	—	—	—
5/81	309	(+)12.7	6.5	(+) 3.4	0.52	(+) 14.4
7/81	384	(+) 3.4	6.4	(+) 8.8	0.65	(+) 6.8
12/81	280	(+)19.8	7.2	(+)20.8	0.50	(+) 30.6
4/82	347	(+)11.6	6.9	(+) 4.4	0.61	(+) 11.6

¹SO₂ monitor range: 0 - 1500 ppm SO₂; NO monitor range 0 - 1000 ppm NO; O₂ monitor range: 0 - 10% O₂ and 0 - 25% O₂.

²The test data for 6/80 were obtained from the initial monitoring system Performance Specification Test. All subsequent test results were obtained during the implementation of the Appendix F performance audit program.

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TABLE 5. con't.

Note: The "Effluent Concentration" values are the average Reference Method test result obtained during the six-run relative accuracy test. "Emission Levels" were computed using the procedures presented in Reference Method 19 from the Reference Method results and are expressed in units of lbs pollutant per million Btu.

The "+" or "-" in parentheses before the RA values indicate whether the monitor responses were greater than (+) or less than (-) the Reference Method test results. Channel relative accuracy determinations were performed in accordance with the procedures prescribed in Performance Specification 2, Appendix B, 40 CFR 60. System relative accuracy determinations were performed in accordance with the proposed revisions to Performance Specification 2 and 3 published in the Federal Register, January 26, 1981. For both the channel and system relative accuracy determinations, six runs were performed instead of nine runs.

3.3 CYLINDER GAS AUDIT PROCEDURE

1. The CGA one-time calibration gas injection test provided the same indication of CEM performance as the complete calibration error test.
2. The two-point calibration gas check for pollutant monitors (50% and 90% of monitor span) frequently did not provide a calibration check at the normal operating range of the monitor, because in many cases, the normal operating range of the monitor was approximately 25% of monitor span.
3. Insufficient data have been collected to determine the appropriateness of the CGA decision limit (i.e., CEMS data are considered accurate if the CGA data accuracy values are within $\pm 10\%$).

3.4 RELATIVE ACCURACY AUDIT VERSUS CYLINDER GAS AUDIT

Insufficient data have been collected to determine whether CGA and RAA provide equivalent results.

4. DISCUSSION OF RESULTS

The two main segments of the performance audit program are: (1) the calibration error determinations for monitors that accept calibration gases, and (2) relative accuracy tests for all CEMS. To ascertain the adequacy of the Appendix F procedures, more comprehensive procedures than those described in Appendix F were used. No audits were performed without the source representatives stating that the CEMS was apparently functioning properly.

Stratification testing was performed before the relative accuracy test during the first performance audit at each source to ensure that the samples obtained during the Reference Method testing of the RAA were representative of the average effluent concentration sampled by the CEMS. Each monitor/Reference Method sampling location was determined to be nonstratified; a detailed discussion of the stratification testing results is presented in Appendix C of this report. Appendix D contains the stratification testing methodology, and Appendix E presents a description of the extractive monitoring system used for the stratification tests.

The following paragraphs present and discuss the results of the performance audits conducted during the first phase of the program. Section 4.1 presents the results of the periodic six-run RAAs for each of the CEMS included in this study. Section 4.2 provides a comparison of six-run and nine-run system relative accuracy assessments, and monitor channel relative accuracy assessments. Section 4.3 compares CGA results with complete calibration error determinations and presents test results regarding the addition of a third audit point for pollutant monitors. Section 4.4 discusses the relationship between the CGA and RAA data accuracy assessment tests.

All computations and results involving the use of monitor data utilized information extracted from strip charts. Each installed CEMS was also equipped with a data acquisition and printout computer system; however, averaging times, response times, etc. within each system prohibited identical matching of Reference Method testing results and monitor responses presented on the computer printouts. All emission levels derived from Reference Method test results and CEMS concentration data were computed using the equations, variables, and conversion factors presented in Reference Method 19.

4.1 ADEQUACY OF QUARTERLY ACCURACY ASSESSMENTS

Tables 1 through 5 present the six-run RAA results for each of the CEMSs included in the performance audit program. Exceedance of the 25% system relative accuracy limit specified in Appendix F was observed: (1) in two consecutive audits of the Contraves-Goerz SO₂/CO₂ CEMS and (2) in one of the audits of a Lear Siegler NO/O₂ CEMS. These same monitors had previously successfully completed the required Performance Specification test of Appendix B, 40 CFR 60, and had successfully passed at least one previous Appendix F RAA. Tables 1 through 5 show that significant changes in RAA results are observed for individual pollutant and diluent monitoring channels, as well as for the combined monitoring system. If a change of 10% relative accuracy is used as a criterion for indicating that a significant change in monitor accuracy has occurred between consecutive audits, then the available test results show that significant changes are observed in 11 of 24 cases (46%) for pollutant

monitoring channels; in 5 of 8 cases (62%) for diluent monitoring channels; and in 7 of 13 cases (53%) for the combined pollutant-diluent monitoring systems.

Although source representatives indicated that the CEMS was functioning properly, the audit results showed that this assessment was not always correct. If the audits had not been performed quarterly (an approximate time interval), the installed monitors would have continued to produce erroneous data without the source's knowledge that a problem existed. Furthermore, when corrective action was needed, as illustrated by the results of RAA for the Contraves-Goerz CEMS (Table 3), timely corrective action was either not implemented or was not effective. A description of the problems of the Contraves CEMS is provided in a letter from Contraves-Goerz to EPA, dated September 8, 1982 (see Appendix F). Monitor problems, source downtime, and test scheduling difficulties affected the time interval between each CEMS audit.

4.2 RELATIVE ACCURACY AUDIT (RAA) ANALYSIS

The RAA procedure of Procedure 1 is the same as the relative accuracy test procedure prescribed in the proposed Performance Specification 2 (Vol. 46, No. 16, January 26, 1981 Federal Register), except that six rather than nine sets of measurements are required. During the initial segment of the auditing program, nine-run relative accuracy assessments were performed to determine whether the results of these tests significantly differ from six-run assessments; the RAA determinations were calculated from the test results of the first six sets of measurements.

Table 6 presents a comparison of nine-run versus six-run relative accuracy determinations (all measurements are presented on a dry basis). In almost all instances (twelve of fourteen tests), the six-run system relative accuracy results are slightly higher than the nine-run results. These higher results were due to an increase in the 95% confidence interval; eleven of the twelve six-run relative accuracy assessments had higher confidence intervals than the corresponding nine-run assessments. This increase was expected to occur as the "t" value used in the six-run 95% confidence interval computation is larger than the "t" value used in the nine-run confidence interval calculation. The mean difference did not appear to directly affect the relationship between the six-run and nine-run relative accuracy determinations. For seven of the fourteen relative accuracy test comparisons, the six-run mean difference result was higher than the nine-run mean difference result, but for the other half of the tests, the six-run mean difference was less than the nine-run mean difference. Even though the six-run determinations provided higher relative accuracy (error) assessments than the nine-run determinations, the decision that the monitoring system was accurate (i.e., a relative accuracy assessment of $\leq 20\%$ for the nine-run determinations and $\leq 25\%$ for the six-run determinations) was the same for all cases.

Table 6 also presents nine-run and six-run relative accuracy determinations for each portion (pollutant and diluent monitoring channels) of the monitoring system. Comparison of the six-run and nine-run assessments provide basically the same results and conclusions as those provided from the comparison of the system relative accuracy determinations. However, the additional information gained by obtaining the the relative accuracy results for each monitoring channel does provide a much better indication of the monitoring system's behavior.

TABLE 6.

COMPARISON OF SIX-RUN AND NINE-RUN RELATIVE ACCURACY TEST RESULTS
FOR CEM SYSTEMS INSTALLED ON COAL-FIRED BOILERS EQUIPPED WITH FGD

Source/ Test No. Code	CEM Type	Emissions Measured	Mean Reference Method Result	Mean Difference ² 9-Run 6-Run	Confidence Interval ³ 9-Run 6-Run	Relative Accuracy 9-Run 6-Run (%) (Z)	
A/O	DuPont	1b SO ₂ /10 ⁶ Btu	0.40	-0.017	-0.015	0.009 0.013	6.7 8.0
A/1	DuPont	ppm _d SO ₂ %CO _{2d}	150 12.0	146 12.2	12.2 -0.22	5.3 0.08	10.1 13.0 2.3 2.8
P/1	EDC	1b SO ₂ /10 ⁶ Btu	0.57	0.57	0.032	0.017	7.2 9.5
		ppm _d SO ₂ %CO _{2d}	348 9.7	344 9.7	16.5 1.13	18.2 0.16	9.2 11.3 13.1 14.2
		1b SO ₂ /10 ⁶ Btu	1.08	1.06	-0.067	0.056	11.9 12.3
N/O	C-G	ppm _d SO ₂ %CO _{2d}	378 ⁵ 13.1 ⁵	396 12.9	-1.8 ⁵ -1.14 ⁵	20.0 ⁵ 0.90 ⁵	5.8 ⁵ 8.0 15.6 ⁵ 18.1
		1b SO ₂ /10 ⁶ Btu	0.86 ⁵	0.92	0.053	0.087 ⁵	18.8 ⁵ 18.8
N/1	C-G	ppm _d SO ₂ %CO _{2d}	185 12.9	188 13.0	7.7 -0.24	9.3 0.22	9.2 13.0 3.6 4.5
		1b SO ₂ /10 ⁶ Btu	0.43	0.43	0.028	0.015	9.5 12.3
N/2	C-G	ppm _d SO ₂ %CO _{2d}	191 11.3	170 11.2	68.7 -2.33	36.8 1.08	55.2 80.3 30.2 36.3
		1b SO ₂ /10 ⁶ Btu	0.51	0.45	0.470	0.125	99.0 128

TABLE 6. (cont'd.)
COMPARISON OF SIX-RUN AND NINE-RUN RELATIVE ACCURACY TEST RESULTS
FOR CEM SYSTEMS INSTALLED ON COAL-FIRED BOILERS EQUIPPED WITH FCD

Source/ Test No. Code	CEM Type	Emissions Measured	Mean Reference Method Result	Mean Difference 9-Run 6-Run	Confidence Interval 9-Run 6-Run	Relative Accuracy 9-Run 6-Run (%)
S1/0	LSI	ppm _d SO ₂ ppm _d NO _x	377 374 238 234	-57.8 -52.7 -2.9 0.8	8.0 8.2 11.0 10.8	17.5 16.3 5.8 5.0
S1/1	LSI	ppm _d SO ₂ ppm _d NO _x %O _{2d} 1b SO ₂ /10 ⁶ Btu 1b NO _x /10 ⁶ Btu	451 433 404 407 7.6 7.6 1.15 1.10 0.74 0.74	29.6 35.7 -19.6 -12.3 0.20 0.32 0.094 0.122 -0.022 -0.003	18.8 29.6 11.0 11.0 0.21 0.26 0.058 0.083 0.028 0.029	10.7 15.1 7.6 5.7 5.4 7.6 13.2 18.6 6.8 4.3
S1/2	LSI	ppm _d SO ₂ ppm _d NO _x %O _{2d} 1b SO ₂ /10 ⁶ Btu 1b NO _x /10 ⁶ Btu	475 476 318 311 7.2 7.3 1.18 1.18 0.57 0.56	12.1 3.7 25.6 25.8 0.26 0.17 0.052 0.023 0.056 0.052	22.5 30.5 24.5 37.8 0.20 0.14 0.064 0.082 0.050 0.076	7.3 7.2 15.8 20.5 6.4 4.2 9.8 8.9 18.6 22.9
S2/0	LSI	ppm _d SO ₂ ppm _d NO _x	321 343 228 232	-36.2 -46.8 24.9 16.0	24.2 10.7 13.8 15.1	18.8 16.8 17.0 13.4

(cont'd. on next page)

TABLE 6. (cont'd.)

COMPARISON OF SIX-RUN AND NINE-RUN RELATIVE ACCURACY TEST RESULTS
FOR CEM SYSTEMS INSTALLED ON COAL-FIRED BOILERS EQUIPPED WITH FGD

Source/ Test No. Code	CEM Type	Emissions Measured	Mean Reference Method Result		Mean Difference		Confidence Interval		Relative Accuracy	
			9-Run	6-Run	9-Run	6-Run	9-Run	6-Run	9-Run (%)	6-Run (%)
S2/2	LSI	ppm SO ₂	388	388	18.1	14.8	15.3	22.1	8.6	9.5
		ppm NO _x	388	384	-1.0	4.3	8.8	8.6	2.5	3.4
		%O ₂ d	6.5	6.4	0.47	0.48	0.07	0.08	8.3	8.8
		1b SO ₂ /10 ⁶ Btu	0.92	0.91	0.074	0.067	0.038	0.057	12.2	13.6
S2/3	LSI	1b NO _x /10 ⁶ Btu	0.66	0.65	0.017	0.027	0.016	0.017	5.0	6.8
		ppm SO ₂	474	471	-36.6	-33.5	10.1	14.2	9.9	10.1
		ppm NO _x	286	280	17.9	23.7	19.7	31.7	13.1	19.8
		%O ₂ d	7.2	7.2	1.17	1.18	0.21	0.32	19.2	20.8
		1b SO ₂ /10 ⁶ Btu	1.17	1.17	0.009	0.020	0.041	0.056	4.3	6.5
		1b NO _x /10 ⁶ Btu	0.50	0.50	0.088	0.097	0.035	0.056	24.6	30.6

1"Source/Test No. Codes"ending in "0" present results obtained during the initial Performance Specification Test of the installed CEMS. All other test results were obtained during the Appendix F performance audit program.

2 The "Mean Difference" is the algebraic mean of the individual differences which are determined by subtracting the Reference Method result from the corresponding CEM value for each run performed.

3 The "95% Confidence Interval" is calculated from the individual differences (X_i) between the Reference Method results and the corresponding CEM values for each run as:

$$C.I._{.95} = \frac{t_{.975}}{\sqrt{n-1}} \sqrt{n \sum x_i^2 - (\sum x_i)^2}$$

where: n = 6 t_{.975} = 2.571

n = 9 t_{.975} = 2.306

(cont'd. on next page)

- 4 The "Relative Accuracy" (expressed as a %) is calculated as the sum of the absolute value of the mean difference and the 95% Confidence Interval, divided by the mean Reference Method result.
- 5 Only eight sampling runs were performed.

4.3 CYLINDER GASES AUDIT (CGA) ANALYSIS

The CGA procedure of Procedure 1 challenges the monitoring system (both pollutant and diluent monitoring channels) with audit gases of known concentrations as follows: (1) 45 to 55% and 85 to 95% of pollutant monitor span, (2) 5 to 8% CO₂ and 10 to 14% CO₂ and, (3) 1 to 3% O₂ and 6 to 10% O₂. The difference between the actual concentration of the audit gas and the concentration indicated by the monitor is used to assess the accuracy of the monitoring data; a monitor is considered to be accurate if the percent deviations between the audit gas concentrations and monitor responses fall within $\pm 10\%$ of the audit gas concentration.

During this study, full calibration error determinations (Performance Specification 2, Appendix B, 40 CFR 60) were conducted for each monitor channel; the first injection of each calibration error test was used to compute the CGA result. Complete calibration error determinations were performed to determine whether a one-time gas injection provided results similar to the calibration error test results. In addition, three audit gas concentration ranges were used instead of the two prescribed ranges; this additional audit point provided a check of the linearity of the monitor, and for most of the pollutant monitoring channels, a low level gas injection (a 20-30% of monitor span) also provided information close to the normal operating range of the monitor.

Table 7 presents a comparison of the calibration error determinations versus the CGA assessment. The "+/-" in parentheses before the calibration error values denotes whether the mean of the monitor responses was greater than (+) or less than (-) the known concentration of the injected calibration gas, and a "0" in parentheses denotes that the mean difference was zero. This designation is important, because the calibration assessments are computed by summing the absolute value of the mean difference and the 95% confidence interval determined from five gas injections, while the CGA assessment represents a one-time gas injection mean deviation. As is shown in Table 7, the calibration error determinations compare very well with the CGA results. This close agreement is due to the audited monitors' high level of precision during these tests (i.e., the 95% confidence interval was very small in most cases; therefore, calibration error and CGA assessments provided very similar results).

4.4 COMPARISON OF CGA AND RAA ASSESSMENTS

Only two types of monitoring systems investigated during this study are capable of accepting calibration gases: (1) the Lear Siegler system, and (2) the DuPont system. Table 8 presents a comparison of CGA results versus RAA results for these two monitoring systems.

The RAA and CGA assessments did not consistently provide the same indication of CEM performance for the Lear Siegler SM810 SO₂/NO monitor because of the difficulty in injecting gases into the pollutant monitor's ceramic thimble. The current procedure of injecting the calibration gases at 2.0 l/min provides environmental conditions within new thimbles comparable to those of effluent gases diffusing into the thimble during normal operating conditions.

TABLE 7.

COMPARISON OF CALIBRATION ERROR TEST¹ RESULTS AND CYLINDER GAS AUDIT² (CGA)
ERROR ASSESSMENTS FOR CEM SYSTEMS INSTALLED ON COAL-FIRED BOILERS EQUIPPED WITH FGD

Source/ Test # Code	CEM Type	Monitor Channel	LOW RANGE			MIDRANGE			HIGH RANGE		
			Cyl. Gas Conc. (ppm or %O ₂)	Cal. Error (%)	CGA Error (%)	Cyl. Gas Conc. (ppm or %O ₂)	Cal. Error (%)	CGA Error (%)	Cyl. Gas Conc. (ppm or %O ₂)	Cal. Error (%)	CGA Error (%)
S1/0	LSI ⁴	SO ₂ NO	-- --	-- --	-- --	800 430	(-) 3.2 ⁵ (-) 1.3 ⁵	- 2.5 0.0	1370 970	(-) 1.5 ⁵ (+) 0.9 ⁵	0.0 0.5
S1/1	LSI	SO ₂ NO	-- --	-- --	-- --	794 440	(-) 11.4 (-) 12.5	-11.2 -13.6	1314 900	(-) 10.6 (-) 14.5	- 9.8 -15.0
S1/2	LSI	O ₂	0.86	(+) 20.0	10.5	5.38	(+) 4.9	1.9	8.28	(+) 7.6	2.4
S2/0	LSI	SO ₂ NO	-- --	-- --	-- --	776 458	(+) 10.3 (+) 6.0	10.2 5.9	1185 911	(+) 12.4 (-) 1.6	12.1 - 1.9
S2/1	LSI	O ₂	1.1	(-) 9.1	-9.1	7.9	(+) 1.3	1.3	20.9	(-) 0.5	- 0.5
S2/2	LSI	SO ₂ NO	-- --	-- --	-- --	800 520	(+) 0.6 ⁵ (+) 1.0	0.0 0.0	1500 1000	(+) 0.7 ⁵ (+) 0.4 ⁵	0.0 0.0
S2/3	LSI	SO ₂ NO	-- --	-- --	-- --	794 530	(+) 0.5 (-) 1.4	0.1 - 0.9	1300 900	(-) 2.5 (-) 3.6	- 1.9 - 3.3
S2/4	LSI	SO ₂ NO	-- --	-- --	-- --	794 440	(+) 2.8 (+) 4.2	2.6 4.1	1314 900	(+) 5.9 (-) 5.1	5.6 - 3.7
S2/5	LSI	O ₂	0.86	(+) 4.9	2.3	5.38	(+) 6.3	4.1	8.28	(+) 7.0	4.8
S2/6	LSI	NO	--	--	--	458	(+) 35.7	35.4	911	(+) 8.5	7.8
S2/7	LSI	O ₂	1.1	(+) 0.0	0.0	7.9	(+) 19.1	17.7	20.9	(+) 20.8	21.1
S2/8	LSI	SO ₂ NO	368 253	(+) 2.4 (+) 15.6	1.9 -11.1	863 458	(+) 4.4 (+) 5.4	4.3 0.9	1188 911	(+) 4.8 (-) 6.8	4.8 - 7.2
S2/9	LSI	O ₂	1.0	(+) 33.7	18.0	5.06	(+) 14.6	7.1	8.4	(+) 12.2	11.9

TABLE 7. cont'd.

COMPARISON OF CALIBRATION ERROR TEST¹ RESULTS AND CYLINDER GAS AUDIT² (CGA)
ERROR ASSESSMENTS FOR CEM SYSTEMS INSTALLED ON COAL-FIRED BOILERS EQUIPPED WITH FGD

Source/ ³ Test No. Code	CEM Type	Monitor Channel	LOW RANGE			MIDRANGE			HIGH RANGE		
			Cyl. Gas Conc. (ppm or %O ₂)	Cal. Error (%)	CGA Error (%)	Cyl. Gas Conc. (ppm or %O ₂)	Cal. Error (%)	CGA Error (%)	Cyl. Gas Conc. (ppm or %O ₂)	Cal. Error (%)	CGA Error (%)
A/0	DuPont ⁶	SO ₂ O ₂	-- 0.88	-- (+)29.5	-- 25.0	213 8.28	(-) 4.1 (-) 3.0	- 5.2 - 5.8	377 20.9	(+) 4.5 (-) 3.6	- 1.9 - 3.8
A/1	DuPont	SO ₂ O ₂	-- 0.8	-- (+)36.3	-- 25.0	197 8.0	(+) 5.3 (-) 2.8	4.8 - 1.3	390 20.9	(+) 1.5 (+) 4.0	0.3 3.8
A/2	DuPont	SO ₂ O ₂	110 2.7	(+) 9.6 (+)24.4	9.1 22.2	236 7.8	(+) 4.8 (+) 2.6	3.8 2.6	368 20.9	(+) 7.3 (-) 1.4	6.0 -1.4

¹ Calibration Error Test was performed in accordance with 40 CFR 60, Appendix B, Performance Specification 2.

² Cylinder Gas Audits were performed in accordance with Appendix F, Procedure 1.

³ Source/Test No. Codes⁴ ending in "0" present results obtained during the Initial Performance Specification Test of the installed CEMS. All other test results were obtained during the Appendix F performance audit program.

⁴ LSI SM810 SO₂/NO monitor with CM50 O₂ monitor.

⁵ Initial PST for monitor; calibration error determination performed by LSI personnel in the laboratory.

⁶ DuPont 460 SO₂ monitor with Thermox O₂ monitor.

TABLE 8.

COMPARISON OF CGA RESULTS AND SIX-RUN RAA RESULTS FOR
CEM SYSTEMS INSTALLED ON COAL-FIRED BOILERS EQUIPPED WITH FGD

Source/ ¹ No. code	CEM Type	Monitor Channel	RAA Emission Level (ppm; SO ₂ or lb/10 ⁶ Btu)	RAA Result (%)	LOW RANGE Cylinder Gas Concentration (ppm or %O ₂)	CGA Result (%)	MIDRANGE Cylinder Gas Concentration (ppm or %O ₂)	CGA Result (%)	HIGH RANGE Cylinder Gas Concentration (ppm or %O ₂)	CGA Result (%)
S1/0	LSI ²	SO ₂ NO	347 234	(-)16.3 (+)5.0	— —	— —	800 430	-2.5 0.0	1370 970	0.0 0.5
S1/1	LSI	SO ₂ NO O ₂ SO ₂ /O ₂ NO/O ₂	433 407 7.6 1.10 0.74	(+)15.1 (-)5.7 (+)7.6 (+)18.6 (-)4.3	— — 0.86	— — 10.5	794 440 5.38	-11.2 -13.6 1.9	1314 900 8.28	-9.8 -15.0 2.4
S1/2	LSI	SO ₂ NO O ₂ SO ₂ /O ₂ NO/O ₂	476 311 7.3 1.18 0.56	(+)7.2 (+)20.5 (+)4.2 (+)8.9 (+)22.9	— — 1.1	— — -9.1	776 458 7.9	10.2 5.9 1.3	1185 911 20.9	12.1 -1.9 -0.5
S2/0	LSI	SO ₂ NO	343 232	(-)16.8 (+)13.4	— —	— —	800 520	0.0 0.0	1500 1000	0.0 0.0
S2/1	LSI	SO ₂ NO O ₂ SO ₂ /O ₂ NO/O ₂	453 309 6.5 1.06 0.52	(+)14.6 (+)12.7 (+)3.4 (+)16.0 (+)14.4	— — 0.86	— — -1.2	794 530 5.38	0.1 -0.9 -0.6	1300 900 8.28	-1.9 -3.3 1.4

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TABLE 8. cont'd.

COMPARISON OF CGA RESULTS AND SIX-RUN RAA RESULTS FOR
CEM SYSTEMS INSTALLED ON COAL-FIRED BOILERS EQUIPPED WITH FGD

Source/ ¹ Test No. Code	Monitor Channel	RAA Emission Level (ppm; %O ₂ or lb/10 ⁶ Btu)	RA Result (%)	LOW RANGE Cylinder Gas Concentration (ppm or %O ₂)	CGA Result (%)	MIDRANGE Cylinder Gas Concentration (ppm or %O ₂)	CGA Result (%)	HIGH RANGE Cylinder Gas Concentration (ppm or %O ₂)	CGA Result (%)
S2/2 LSI	SO ₂	388	(+) 9.5	—	—	794	2.6	1314	5.6
	NO	384	(+) 3.4	—	—	440	4.1	900	- 3.7
	O ₂	6.4	(+) 8.8	0.86	2.3	5.38	4.1	8.28	4.8
	SO ₂ /O ₂	0.91	(+) 13.6						
	NO/O ₂	0.65	(+) 6.8						
S2/3 LSI	SO ₂	471	(-) 10.1	—	—	776	51.8	1185	OS
	NO	280	(+) 19.8	—	—	458	35.4	911	7.8
	O ₂	7.2	(+) 20.8	1.1	0.0	7.9	17.7	20.9	21.1
	SO ₂ /O ₂	1.17	(+) 6.5						
	NO/O ₂	0.50	(+) 30.6						
S2/4 LSI	SO ₂	408	(+) 9.6	368	1.9	863	4.3	1188	4.8
	NO	347	(+) 11.6	253	-11.1	458	0.9	911	- 7.2
	O ₂	6.9	(+) 4.4	1.0	18.0	5.06	7.1	8.4	11.9
	SO ₂ /O ₂	0.99	(+) 11.3						
	NO/O ₂	0.61	(+) 11.6						
A/O ³ DuPont	SO ₂	—	—	—	—	213	-5.2	377	- 1.9
	O ₂	—	—	0.88	25.0	8.28	-5.8	20.9	- 3.8
	SO ₂ /O ₂	0.40	(-) 8.0						

cont'd. on next page

TABLE 8. cont'd.

COMPARISON OF CGA RESULTS AND SIX-RUN RAA RESULTS FOR
CEM SYSTEMS INSTALLED ON COAL-FIRED BOILERS EQUIPPED WITH FGD

Source/ ¹ CEM Test No. Type Code	Monitor Channel	RAA Emission Level (ppm; SO ₂ or lb/10 ⁶ Btu)	LOW RANGE Cylinder Gas Concentration (ppm or %O ₂)	CGA Result (%)	MIDRANGE Cylinder Gas Concentration (ppm or %O ₂)	CGA Result (%)	HIGH RANGE Cylinder Gas Concentration (ppm or %O ₂)	CGA Result (%)
A/1 DuPont	SO ₂ O ₂ SO ₂ /O ₂	146 12.2 0.57	-- 0.8	-- 25.0	197 8.0	4.8 -1.3	390 20.9	0.3 3.8
A/2 DuPont	SO ₂ O ₂ SO ₂ /O ₂	133 9.4 0.39	110 2.7	9.1 22.2	236 7.8	3.8 2.6	368 20.9	6.0 -1.4

¹ "Source/Test No. Code" ending in "0" indicates that the test results were obtained from initial Performance Specification Test of installed CEM. All other test results were obtained during Appendix F audit program.

² SO₂ monitor range: 0 - 1500 ppm SO₂, NO monitor range: 0 - 1000 ppm NO; O₂ monitor range: 0 - 10% O₂ and 0 - 25% O₂.

³ SO₂ monitor range: 0 - 400 ppm SO₂; O₂ monitor range: 0 - 25% O₂.

Dissimilar environments (i.e., pressure and temperature) cause the monitor to respond incorrectly to the audit gas. However, this injection procedure caused inconsistent and inaccurate results for dirty thimbles with increased pressure drop due to particulate plugging, etc.. A previous injection procedure prescribed that the calibration gas (of a higher concentration than the effluent constituent) be injected at varying flow rates (i.e., 0.5 l/min to 3.0 l/min) until a monitor response plateau was observed; thereby indicating that this was the correct injection flow rate. For flow rates below the correct level, the monitor will be biased low because stack gases will diffuse into the thimble. As the correct flow rate is approached and slightly passed, the monitor will respond accurately. Once the correct flow rate is exceeded, the monitor will be biased high, because over-pressurization causes more gas molecules to be present. Although this second procedure was attempted, it proved unsuccessful during the auditing program.

For the Lear Siegler CM50 O₂ monitor, the CGA and RAA results provided similar indications of monitor performance except at low O₂ concentrations. The CM50 O₂ analyzer is relatively insensitive to calibration gas flow rate; the monitor response is not dependent on the condition of the in-situ filter and varying gas injection flow rates.

For the DuPont SO₂/Thermox O₂ system, CGA and RAA results provided similar indications of monitor performance except at low O₂ concentrations. However, the monitor does not operate at a low level during normal operation. Gas injections must be conducted at specified pressure and flow rate conditions (see manufacturer's monitor operation manual), and the analyzer cabinet has a pressure gauge and flowmeter on the sample line. Therefore, for the DuPont 460 SO₂ monitor/Thermox O₂ monitor, it is a simple procedure to inject the audit gases correctly.

5. TESTING PROCEDURES

Tests were conducted to determine: 1) the precision of the CEMS (i.e., calibration gas check), 2) the relative accuracy of the monitoring system, and 3) whether stratified effluent conditions existed at the monitor/sampling location. The calibration error and relative accuracy results are expressed in units of concentration (ppm) for SO_2 and NO/NO_x continuous emission monitors. During the relative accuracy testing, simultaneous CO_2 or O_2 measurements were taken to determine the relative accuracy of the combined monitoring system channels. EPA Reference Method sampling procedures were utilized to provide the effluent SO_2 , NO_x , O_2 , CO_2 , and moisture concentrations necessary to determine the relative accuracies. Stratification testing was also conducted.

5.1 STRATIFICATION TESTING

To ensure good correlation between monitor and Reference Method concentration values, a stratification test was conducted before the initiation of the relative accuracy testing. A transportable extractive monitoring system (equipped with a NO/NO_x analyzer, an SO_2 analyzer, an O_2 analyzer and a CO_2 analyzer) was used to measure the NO , SO_2 , O_2 and CO_2 effluent concentrations, as appropriate, at a number of points spaced along a stack diameter at the monitor installation locations. The transportable system is described in Appendix E of this report.

The stratification test procedure used two stainless steel sampling probes located in the same plane as the monitoring system. The "reference" probe was inserted at the centroid of the stack; the "traverse" probe was moved along the diameter(s) of the stack. This procedure is necessary to account for temporal variations of the effluent constituents. A detailed description of the procedure is presented in Appendix D.

5.2 CALIBRATION GAS CHECK

A precision check was performed by conducting calibration error tests. For the pollutant monitors, five nonconsecutive gas injections of a zero, low, mid, and high range calibration gases were performed. The calibration error test results were determined according to the procedures of Performance Specification 2 (40 CFR 60, Appendix B).

5.3 RELATIVE ACCURACY TESTING

Monitor relative accuracy tests comprised of nine sampling runs were conducted. Each sampling run consisted of an SO_2 sample, three individual NO_x samples (if applicable), a CO_2/O_2 determination, and a moisture determination, all run concurrently. Only one sampling run per hour was performed.

All samples were extracted at a location adjacent to the monitoring systems (Figures 1 through 5). Separate sampling probes and sampling trains were employed for the SO_2 , NO_x , CO_2/O_2 , and moisture measurements. Sampling

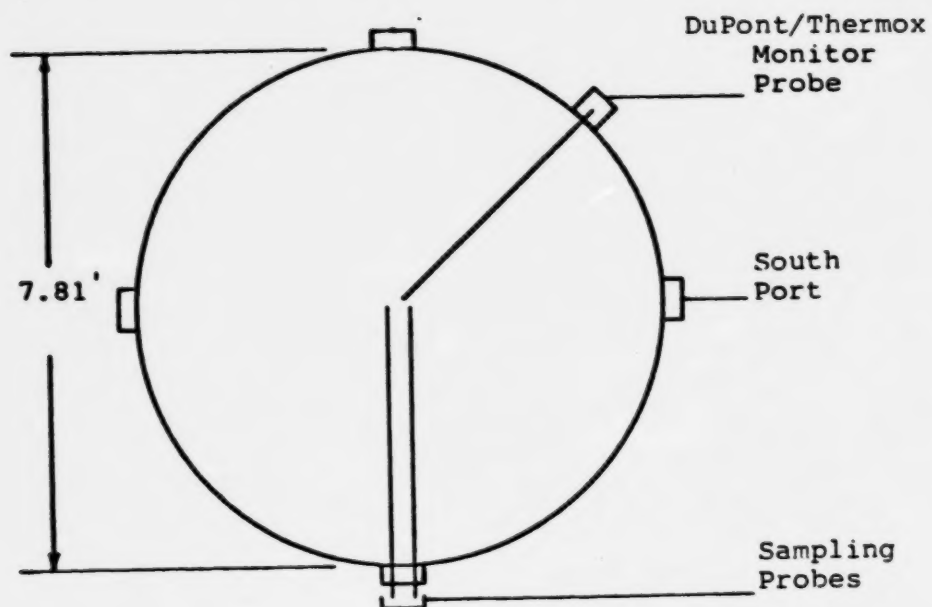


Figure 1. Relative Accuracy Sampling Point for Source "A"

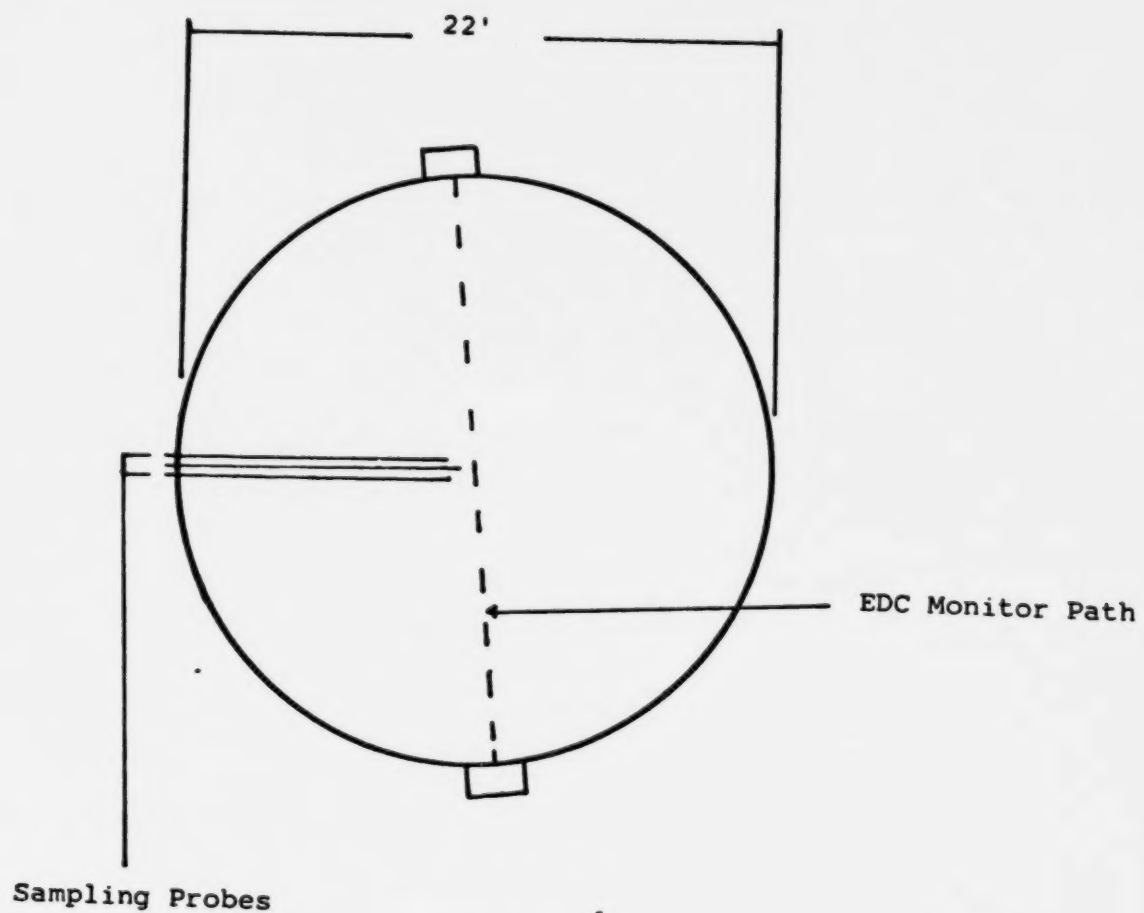


Figure 2. Relative Accuracy Sampling Location for Source "p"

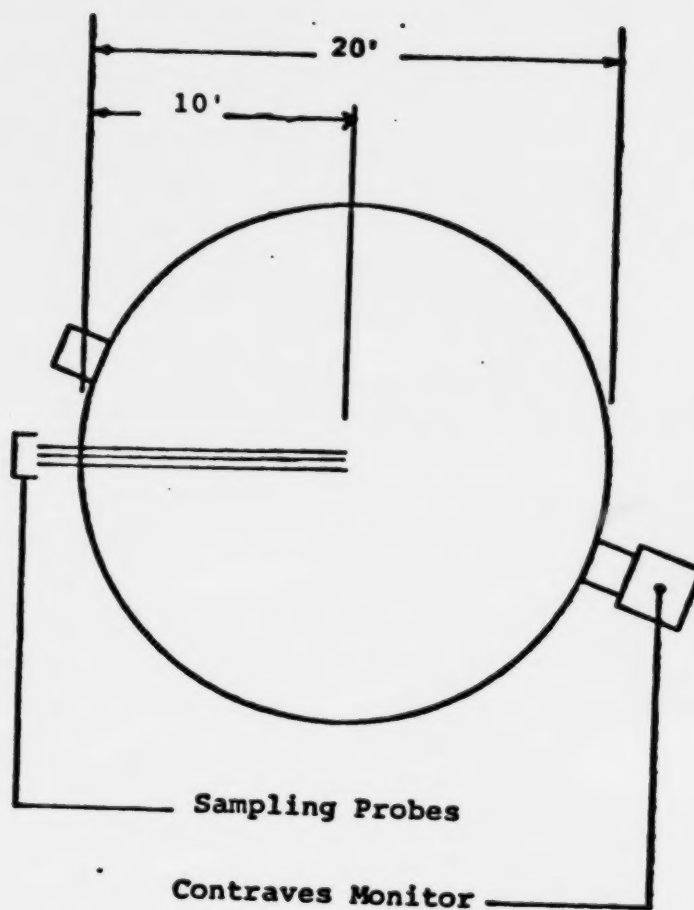


Figure 3. Relative Accuracy Sampling Location for Source "N"

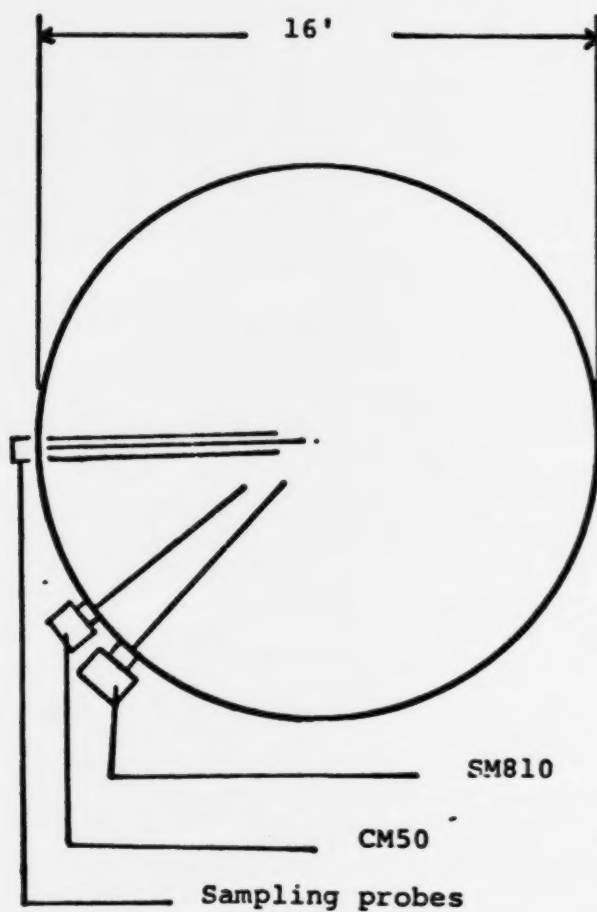


Figure 4. Relative Accuracy Sampling Location for Source "S1"

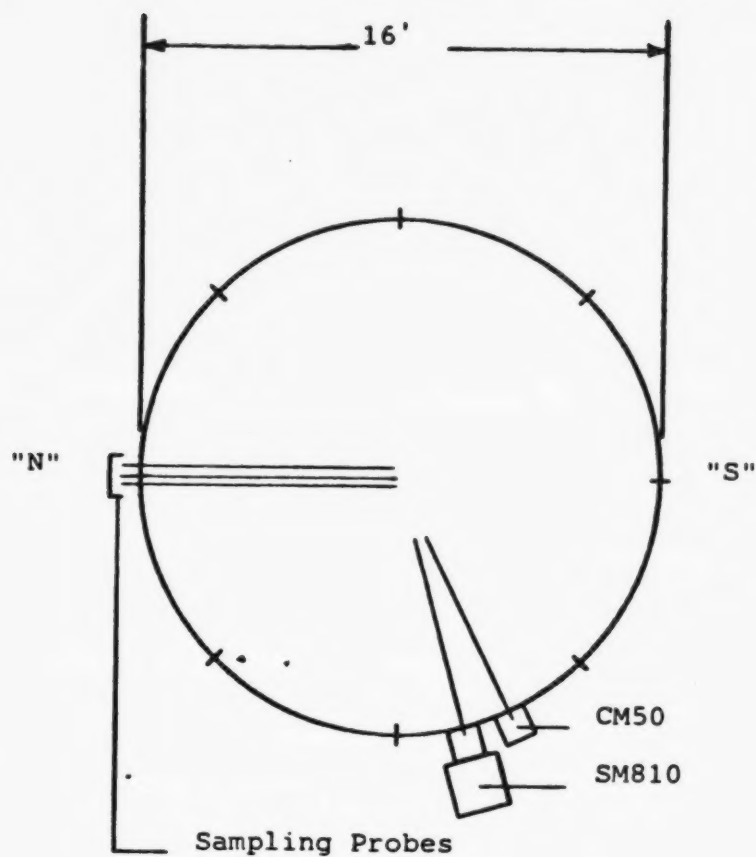


Figure 5. Relative Accuracy Sampling Location for source "82"

probes were constructed of 316 stainless steel; the SO_2 , NO_x , and moisture sampling probes were heated to prevent condensation of effluent moisture during the sampling runs.

The concentration of SO_2 was determined using EPA Method 6 (Appendix A, 40 CFR 60). For each SO_2 run, sampling was conducted for a 20-minute period at a sampling rate of approximately one liter per minute. Following each run, the sampling train was purged with ambient air for 15 minutes. The contents of the first impinger were discarded. Sample analysis according to the procedures of Method 6 was performed on site or in Entropy's laboratory.

The concentration of NO_x was determined using EPA Method 7 (Appendix A, 40 CFR 60). For each NO_x run, three grab samples were extracted from the stack at approximately two minute intervals. Sample analysis was performed in Entropy's laboratory, according to the procedures of Method 7.

Moisture sampling was conducted to facilitate conversion of the wet basis monitor measurements to a dry basis to enable a direct comparison between the continuous monitoring measurements and Reference Method results. The moisture sampling was conducted according to the procedures described in "An Alternative Method for Stack Gas Determination" (written by Jon Stanley and Peter R. Westlin) and EPA Reference Method 4 (Appendix A, 40 CFR 60). Moisture sampling was conducted at a rate of approximately two liters per minute. Each moisture sampling run included the time period required to collect the corresponding SO_2 , NO_x , and CO_2/O_2 effluent samples.

The concentration of CO_2/O_2 was determined using EPA Method 3 (Appendix A, 40 CFR 60). For each CO_2/O_2 run, an integrated sample was extracted from the effluent stream during the same period as the moisture sampling runs. The CO_2/O_2 analysis was performed following each sampling run using an Orsat apparatus.

5.4 QUALITY ASSURANCE

In addition to the quality assurance procedures specified in the Reference Methods (i.e., leak checks, meter box calibrations, etc.), audit samples were routinely analyzed during the test program. Each individual analyzing Reference Method test samples analyzed two or more audit samples before analyzing the test samples to provide a check of analytical technique and standards. These results determined whether the analytical procedures and standards were of sufficient quality to produce valid test sample concentrations, or whether corrective actions should be implemented prior to Reference Method sample analysis. Analyses for the SO_2 audit samples were required to be within $\pm 5\%$ of the known value and analyses for the NO_x audit samples were required to be within $\pm 10\%$ of the known value. The CO_2 and O_2 audit sample analyses were required to be within $\pm 0.2\% \text{ CO}_2/\text{O}_2$ of the known value of the audit samples.

After establishing the effectiveness of the CO_2/O_2 analytical technique, each Orsat analysis was validated through the use of the F_o technique. Depending upon the types of fuel burned, the ratio of the O_2 to CO_2 concentrations $[(20.9 - \% \text{O}_{2d})/(\% \text{CO}_{2d})]$ will equal a constant value. If the calculated ratio was within $\pm 5\%$ of the expected value, the CO_2 and O_2 measurements were considered valid.

APPENDICES

APPENDIX A.

SOURCE DESCRIPTIONS

APPENDIX A.

SOURCE DESCRIPTIONS

A.1 SOURCE "A" DESCRIPTION

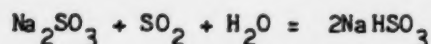
Continuous emission monitor performance evaluations were conducted for a time-shared DuPont monitoring system installed to measure SO_2/O_2 emission levels from the exhaust stacks serving three FGD controlled coal-fired boilers (Units #2, #3, and #4). The three units are of the same configuration and employ identical exhaust cleaning systems (Figure A-1). During normal operating conditions, two of the boilers are run at constant steam production rates while the third boiler's output is varied in order to meet changing load conditions. Each boiler has a rated capacity of 350,000 lbs steam (at 700 psi, 700°F). The "swing boiler" generally operates between 100,000 lbs steam and 325,000 lbs steam; the normal, steady operating output is approximately 240,000 lbs steam for each of the two base load boilers. Each of the three units is operated as the "swing boiler" on a rotating basis.

The DuPont monitoring system is time-shared between the exhaust stacks for Units #2, #3, and #4. All testing for this study was conducted on Unit #3. Figure A-2 presents a scaled drawing of the exhaust stacks serving the three boilers. The stacks (7.81 feet in diameter) extend 225 feet above ground level; the monitoring system's extractive probes and sampling ports are located 87 feet (11.1 stack diameters) upstream of the stack outlet and 63 feet (8.1 stack diameters) downstream from the outlet of the reheater.

The monitor/sampling location consists of four sampling ports (three feet above the sampling platform) placed 90° from one another. The extractive monitor sampling probe is located between (45°) two of the sampling ports. (See Figure C-1, Appendix C for exact placing of the monitor sampling probe.) The monitor probe extends to the center of the cross-sectional area of the stack.

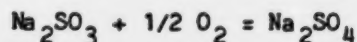
A.1.1 SO_2 Scrubber Description

Source "A" utilizes FMC's patented concentrated double alkali process for sulfur dioxide control. In the double alkali process, sulfur dioxide is absorbed according to the following reaction:



sodium sulfite + sulfur dioxide + water = sodium bisulfite

An important additional reaction is the oxidation of sodium sulfite:



sodium sulfite + oxygen = sodium sulfate

The sulfate ion, which is not active in absorbing sulfur dioxide, can be partially precipitated by reaction with calcium hydroxide. The remaining

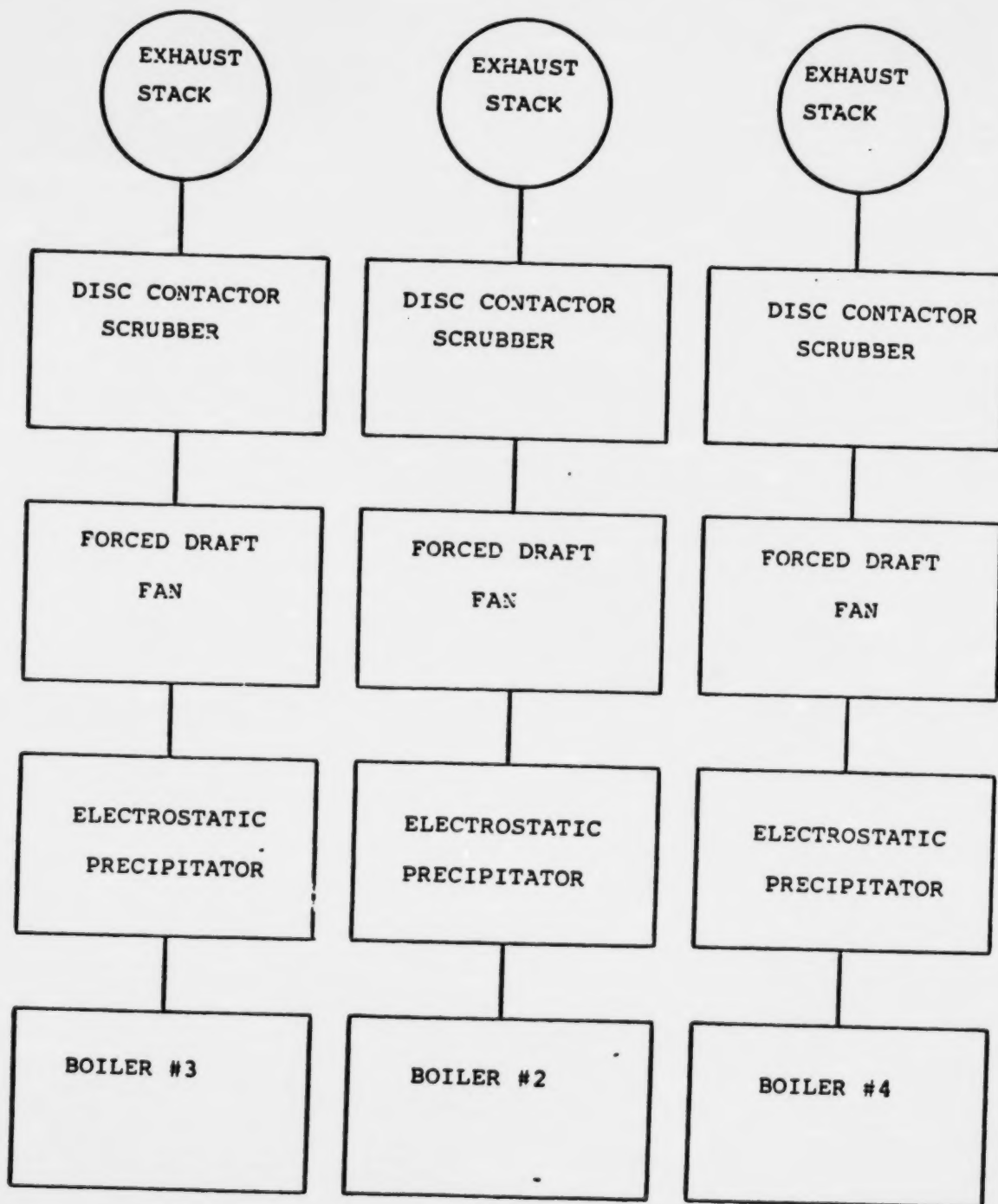


Figure A-1. Block Diagram for Source "A"

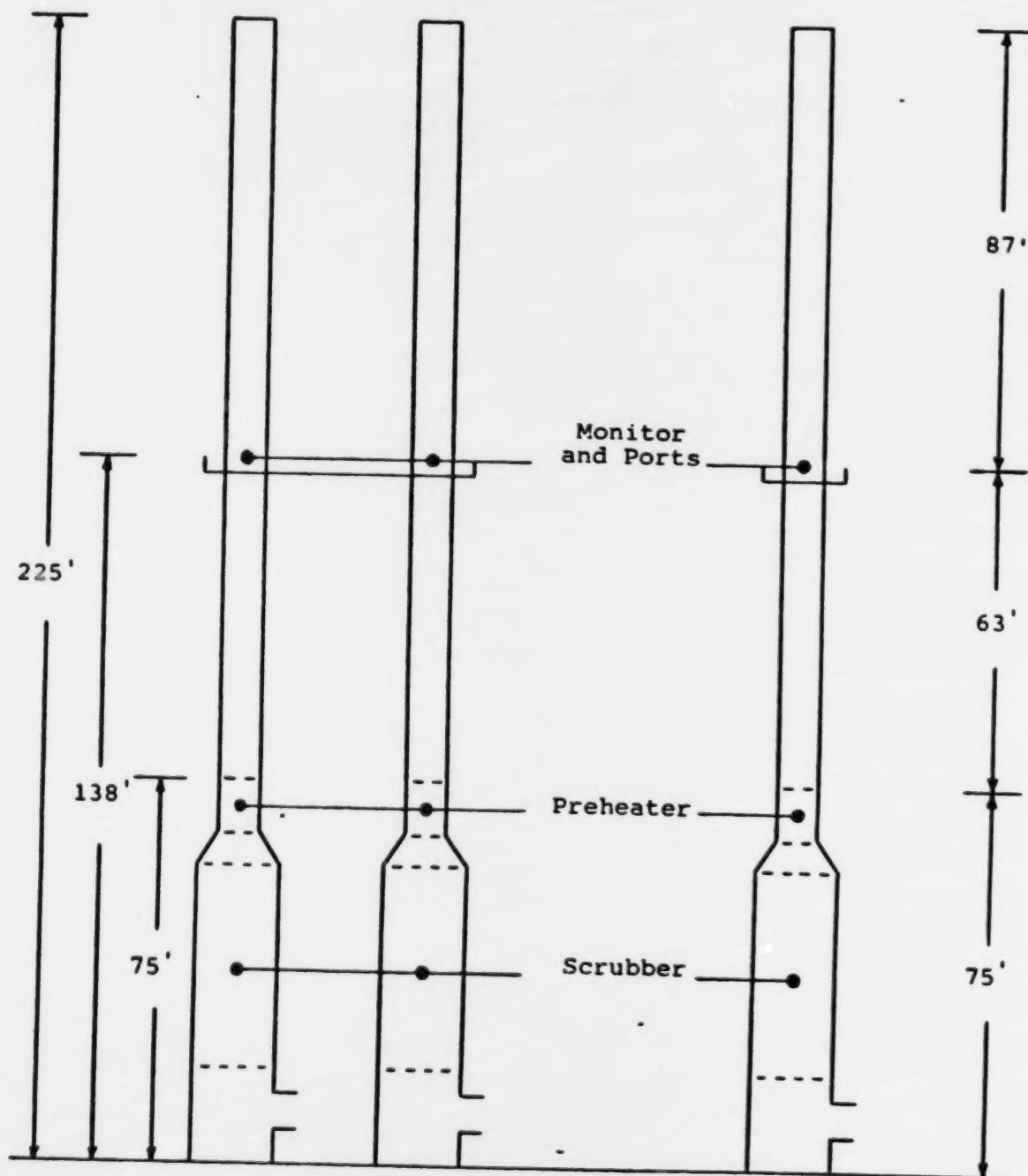


Figure A-2. Monitor and Sampling Port Locations for Source "A"

sodium sulfate is purged from the process through entrainment of solution in the dewatered calcium sulfite/sulfate solids sent to the landfill.

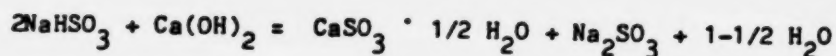
The pH of the scrubbing solution is controlled at 6.5. At this pH, the scrubbing solution contains equimolar concentrations of sodium sulfite and sodium bisulfite. This equimolar solution is highly buffered and can accept rapidly changing flue gas inlet conditions caused by swings in boiler load and/or changes in coal composition without upsetting the process control. As sulfur dioxide is absorbed, the ratio of bisulfite to sulfite increases, causing a decrease in pH. A bleed stream from the absorber recirculation loop is directed to the lime reactor, and the absorber reservoir is replenished with regenerated sodium sulfite which maintains the scrubbing solution pH at 6.5. Maintaining pH levels in a range of 6.2 to 6.8 is important for several reasons. At a pH above 7.0, carbon dioxide absorption becomes significant and can lead to carbonate scaling. At a pH below 6.0, the vapor pressure of sulfur dioxide increases dramatically and can lead to equilibrium-inhibited sulfur dioxide collection.

The sulfur dioxide absorption is accomplished in FMC's proprietary absorber. This absorber is designed to allow high sulfur dioxide collection efficiencies at a relatively low pressure drop without the use of spray nozzles. Collection efficiencies above 92% have been demonstrated while operating at less than 12.7 cm (5 inches) of water pressure drop.

Each absorber is 17.3 feet in diameter, 65 feet tall from base to reheat chamber bottom, and designed for a superficial gas velocity of 9 ft/sec. The internals of this counter-current absorber consist of four stages of disc and doughnut baffles. The vessel is constructed of carbon steel, lined with a glass-flake-reinforced polyester resin, with the exception of the bottom doughnut and inlet plenum which are constructed of Hastelloy G for high temperature protection. The bottom five feet of the vessel serve as an integral sump for the scrubbing liquor. The absorber is lined with acid brick from the floor to the bottom doughnut for temperature protection. Two stages of chevron-type mist eliminators are installed at the top of the vessel to remove entrained scrubbing liquor from the gas stream.

A rubber-lined recirculation pump draws liquor from the sump and delivers it to either of the top two stages. It also provides a bleed stream to the regeneration area. A full-flow standby recirculation pump is provided for the absorber. The recirculation system is designed to provide an L/G of 10 (gal/1000 acf). Bleed flowrate is controlled to maintain a constant absorber sump level. Recirculation liquor pH is controlled at 6.5 by addition of high pH regenerated liquor to the scrubber sump. All recirculation and bleed piping is constructed of fiber glass-reinforced polyester designed for corrosion and abrasion resistance.

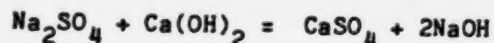
Sodium bisulfite in the bleed stream is reacted with slaked lime to precipitate calcium sulfite as well as regenerate sodium sulfite for use in the absorber according to the following reaction:



sodium bisulfite + calcium hydroxide =

calcium sulfite + sodium sulfite + water

A small portion of the sodium sulfate in the bleed stream also reacts with slaked lime to form calcium sulfate and regenerate sodium hydroxide.



Sodium sulfate + calcium hydroxide calcium sulfate + sodium hydroxide

Unreacted sodium sulfate is purged from the process via entrained solution in the dewatered calcium sulfite/sulfate waste product. Calcium sulfate typically accounts for 10% or less of the filter cake solids.

A.2 SOURCE "P" DESCRIPTION

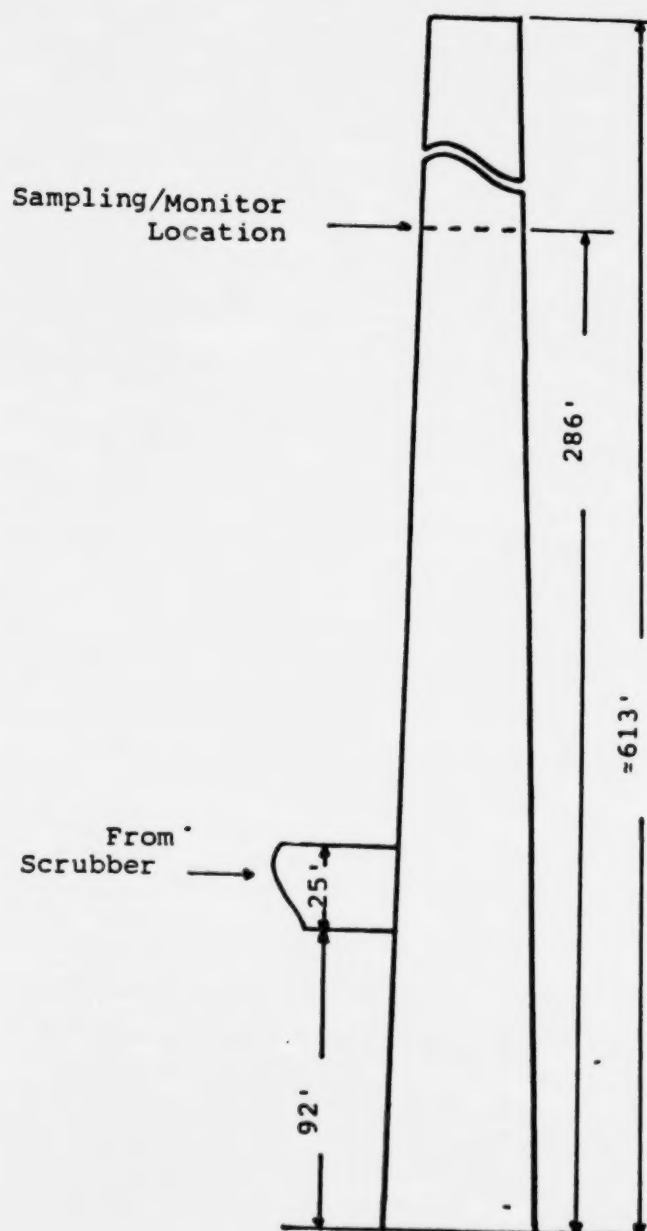
Continuous emission monitor performance evaluations were conducted for an EDC DIGI Series 1400 gas emissions monitor. Testing was conducted on the effluent from a FGD controlled, coal-fired electric utility boiler (Unit #3). The generating unit has a rated capacity of 585 megawatts; the output of the unit normally ranges from 550 to 580 megawatts.

The effluent from the boiler passes through an ESP and an FGD scrubber before being exhausted into the atmosphere. The masonry exhaust stack is approximately 612 feet tall; the monitor and four sampling ports are located approximately 169 feet above the effluent inlet into the stack (Figure A-3). The monitoring location is 7.7 stack diameters downstream of the stack breeching and 14.9 stack diameters upstream of the stack outlet. The sampling ports are four inches in diameter, and are located 90 degrees from one another.

A.3 SOURCE "N" DESCRIPTION

Continuous emission monitor performance evaluations were conducted for a Contraves Goerz GEM-1 gas emissions monitor installed on an FGD controlled coal-fired electric utility boiler (Unit #1). The generating unit has a rated capacity of 617.4 megawatts; normal output ranges from 550 to 580 megawatts. The unit combusts Illinois bituminous coal having a 2.8 percent sulfur content.

The effluent from the boiler passes through an ESP and an FGD scrubber before being exhausted into the atmosphere (Figure A-4). The steel exhaust stack is approximately 300 feet tall; the monitor and four sampling ports are located approximately 50 feet from the top of the stack (Figure A-5). The monitoring location is 7.5 stack diameters downstream of the stack breeching and 2.5 stack diameters upstream of the stack outlet. The sampling ports are six inches in diameter, and are located 90 degrees from one another.



Profile View:

Figure A-3. Monitor and Sampling Port Locations for Source "P"

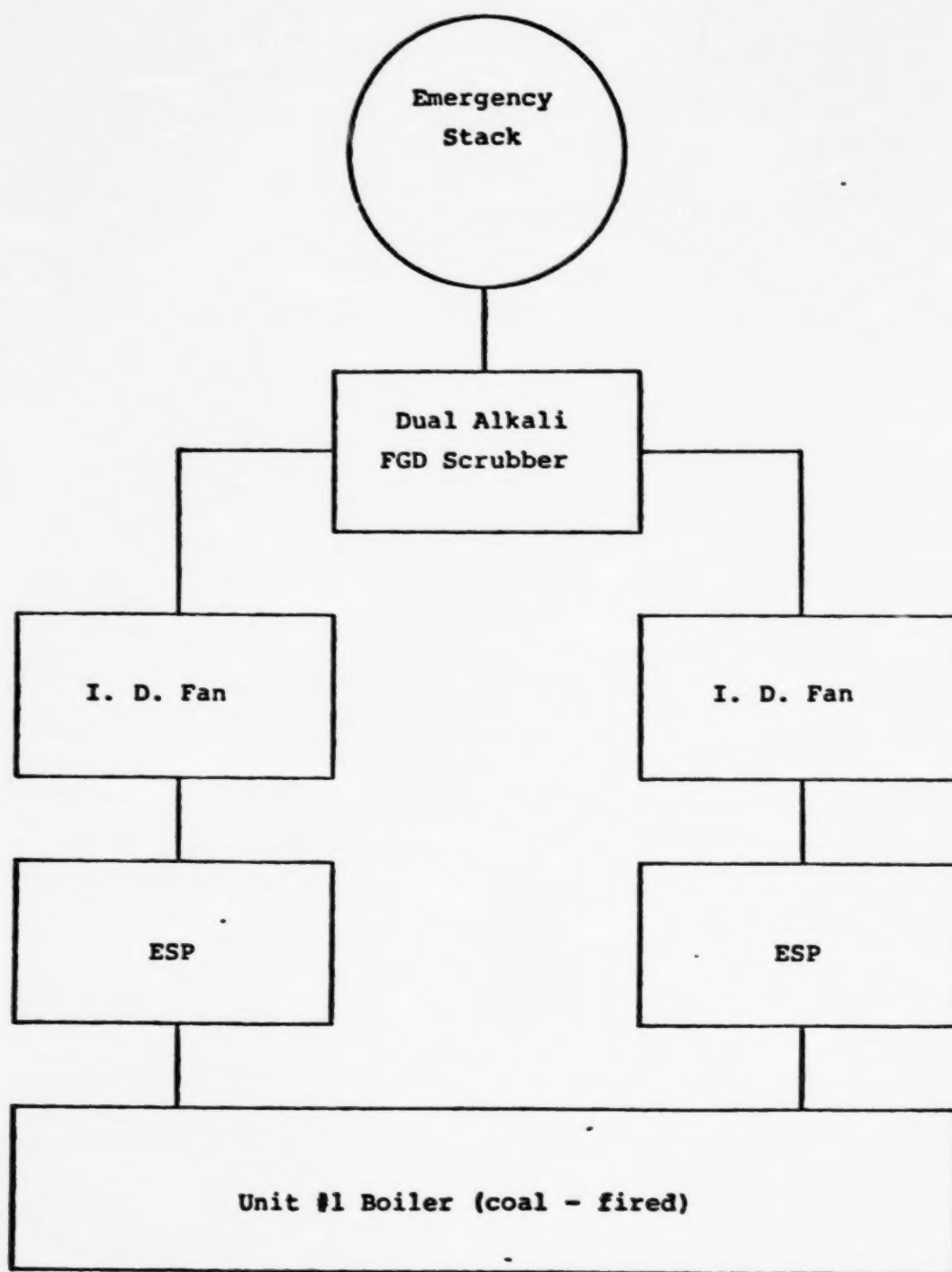


Figure A-4. Process Block Diagram for Source "N"

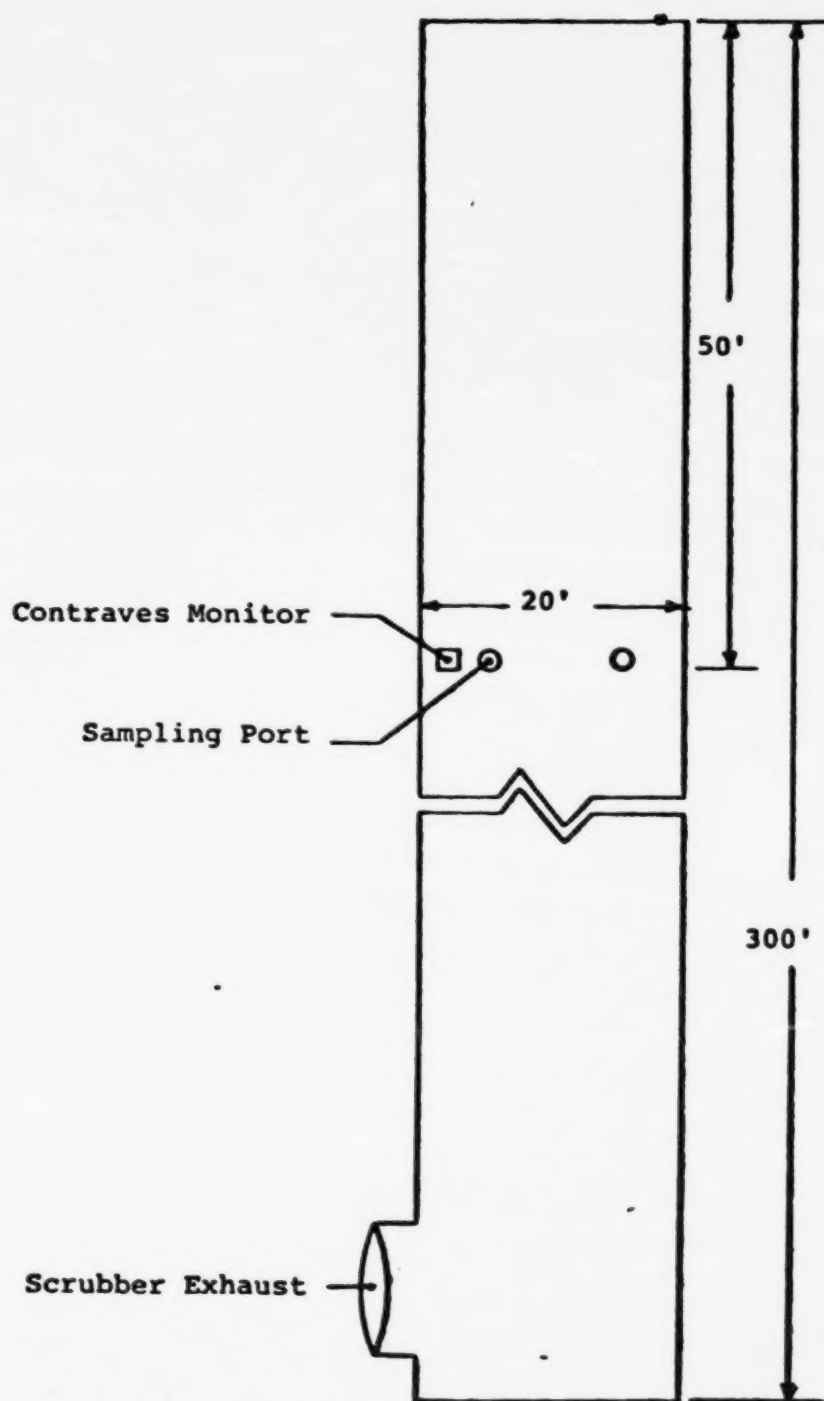


Figure A-5. Monitor and Sampling Locations for Source "N"

A.3.1 CEM Quality Assurance Program

Source "N" utilizes a very simple QA program to maintain the accuracy of the Contraves Goerz GEM-1 SO₂/CO₂ monitoring system. Every 24 hours, the monitor automatically cycles through a calibration check: an internal gas cell is viewed by the monitor, and the monitor indicates a concentration response (a SO₂ and CO₂ value). If the monitor response is not within $\pm 10\%$ of the desired response, the instrument technician adjusts the monitor to respond correctly to the gas cell. The only other QA action performed by the source is the changing of the air purge system filters every two months.

A.4 SOURCE "S1" AND "S2" DESCRIPTION

Continuous emission monitor performance evaluations were conducted for the two Lear Siegler, Inc. SM810 SO₂/NO and CM50 O₂ monitoring systems installed to measure emission levels from the twin exhaust stacks of two identical, FGD controlled coal-fired electric utility boilers. ("S1" is Unit #1 and "S2" is Unit #2.) The boilers fire bituminous coal with an average sulfur content of 0.7 percent. The rated capacity for the generating units is 180 megawatts; electrical output normally remains relatively steady at approximately 150 megawatts.

The effluent stream from each boiler passes through an electrostatic precipitator (ESP) and a wet limestone scrubber before being exhausted to the atmosphere through a 400-foot concrete stack. The effluent stream from the ESP is conveyed to the wet limestone scrubber through a pair of square ducts, each equipped with an induced draft fan. The LSI emission monitors under investigation and the sampling ports are located approximately 102 feet (6.4 stack diameters) upstream of the stack outlet and approximately 170 feet (8.8 stack diameters) downstream from the stack breechings (Figures A-6 and A-7).

A.4.1 SO₂ Scrubber System

Sources "S1" and "S2" have identical "Venturi-Rod Scrubber" SO₂ scrubbers. Each scrubber is capable of handling 100% of the boiler exhaust₂ stream for operating loads up to 62% of rated boiler capacity. At higher production rates, the excess effluent gas is bypassed around the scrubber and recombined with the scrubbed gas stream before entering the stack.

The rod type scrubber has four stages of rod decks having dimensions of 10 feet by 40 feet square at 10 foot intervals. The shell is of carbon steel and is presently lined with chlorabutyl rubber and Hastelloy G. The rods are 316-L stainless with Hastelloy G supports. Gas flow from each boiler unit, at maximum design flow, is 1,228,000 CFM at 825° F. By heat transfer through the air heaters downstream of the ESP, gas flow is reduced to slightly in excess of 700,000 CFM with the scrubber designed to take approximately 442,000 CFM at 270°F. The liquid to gas ratio specification is 55. The ventri rod deck consists of stainless steel pipes 1-5/16" OD in a plane perpendicular to gas flow and are spaced approximately 3/4" apart. When all conditions are under control, the system develops a pressure drop of 6 inches H₂O. The mist eliminator is a Chevron type with 2 stages and 3 passes per stage. The unit is designed for 85 percent removal of SO₂. The slurry pH at the scrubber inlet is maintained within a range of 5.2 - 6.0; the slurry pH at the scrubber outlet is maintained within a range of 4.0 - 5.0.

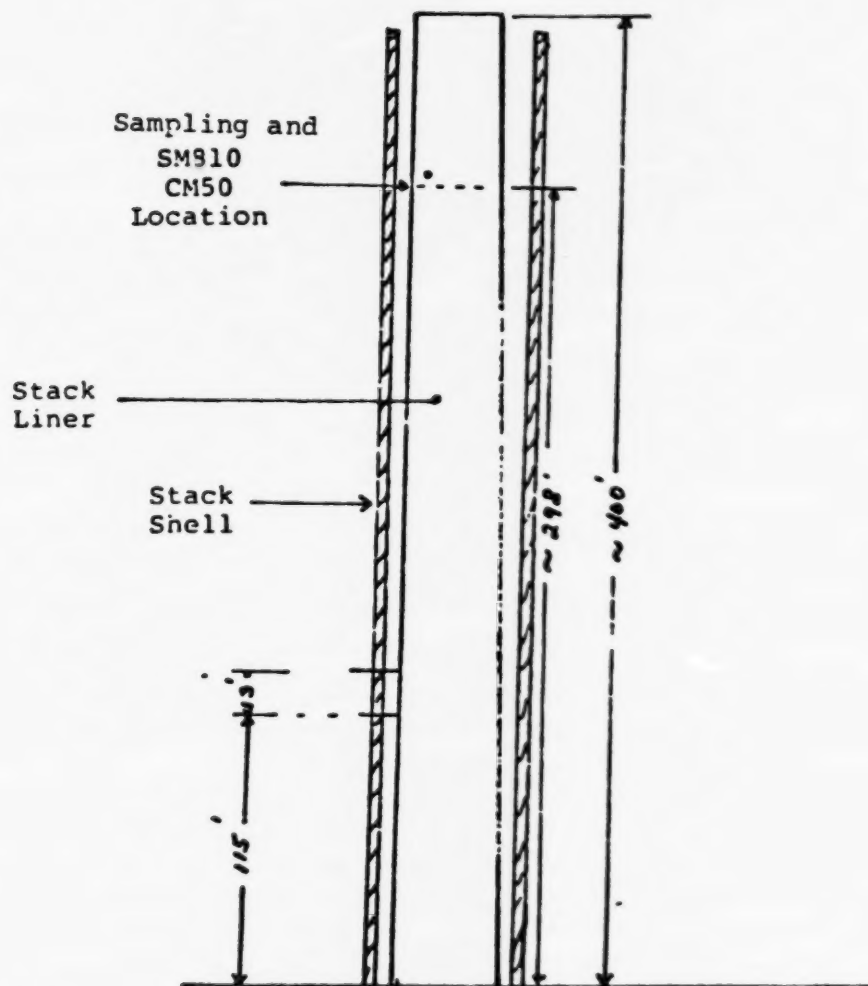


Figure A-6. Monitor and Sampling Location for Sources "S1" and "S2"

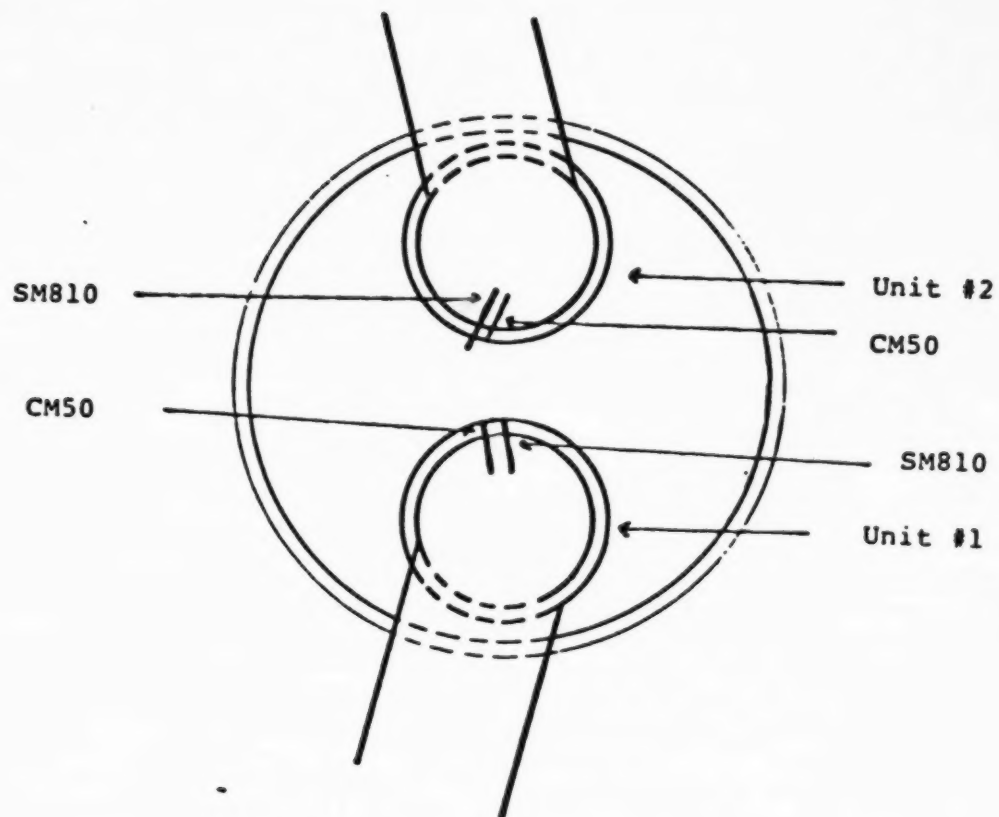


Figure A-7. Cross-Sectional View of Monitor Location for Sources "S1" and "S2"

APPENDIX B.

INSTALLED MONITOR DESCRIPTIONS

APPENDIX B.

INSTALLED MONITOR DESCRIPTIONS

B.1 DUPONT/THERMOX MONITORING SYSTEM

The DuPont 460 SO₂ gas analyzer is an extractive monitor which measures concentrations of sulfur dioxide through the use of differential ultraviolet radiation absorption. The basic operation of the monitor entails sequential cycling through a sampling mode and a purge mode for the SO₂ monitoring channel. First, a sample is withdrawn from the effluent stream through a single point sampling probe equipped with filters for the removal of particulate matter. The sample is then transported to the analyzer via heated sample lines maintained at approximately 300°F. Next, the sample passes through a condensation trap and then into a sample cell (heated to approximately 220°F), where the SO₂ concentration is measured by differential absorption of ultraviolet radiation. During the purge cycle, ambient air is introduced into the sample cell and back flows through the sampling line and sampling probe. The monitor performs automatic adjustments of its zero measurement during the purge cycle.

The Thermox O₂ monitor is an extractive analyzer which employs an electrocatalytic process in the analysis of oxygen. The Thermox O₂ monitor is installed within the DuPont 460 analyzer cabinet, in a functionally parallel arrangement with the SO₂ sample cell. During the sampling cycle, sample gases enter the analytical chambers of both the DuPont and the Thermox monitors simultaneously; thus, concurrent SO₂ and O₂ measurements are obtained during each sampling cycle of the analyzer.

In the Thermox O₂ monitor, the partial pressure of the oxygen in the sample side of the cell is lower than the partial pressure of the oxygen in the reference side, which is generally that of air. When the cell is kept at a temperature of about 1560°F, oxygen molecules on the reference side will pick up electrons at the electrode-electrolyte interface. The cell is composed of porous ceramic material, which has the special property of high conductivity for oxygen ions. This occurs because the metal ions form a perfect crystal lattice in the material, whereas the oxygen ions do not, resulting in vacancies. Heating this material causes the vacancies and oxygen ions to move about. The oxygen ions migrate to the electrode on the sample side of the cell, release electrons to the electrode, and emerge as oxygen molecules. The EMF from this process, expressed in terms of the oxygen partial pressure, is given in units of concentration (% O₂).

The analyzer cabinet and control units for the DuPont 460 SO₂ and Thermox O₂ monitors are housed in a small structure alongside the base of the stacks. The electrical signals are transported to strip chart recorders located in the boiler control room. Also, Source "A" has incorporated a data acquisition/computer system in conjunction with the strip chart recorder in order to facilitate computation and recording of SO₂ emission levels in units of lbs SO₂/10⁶ Btu for each stack.

Since the DuPont-Thermox monitoring system does not measure the SO₂ and O₂ concentrations on a dry basis, a method to determine the moisture content of the monitor's sample stream is required. The stack exhaust stream (at

approximately 112°F) is supersaturated (i.e., containing entrained water droplets), and thus the extractive monitor probe collects water droplets in addition to the exhaust gases. The sample stream is transported to the monitor through heated lines (at approximately 300°F); therefore, the moisture content of the sample stream going to the monitor is greater than the stack gas moisture content. As the sample stream passes through the monitor, it initially flows through a condensation trap (at approximately 84°F) before entering the measurement chamber (at approximately 220°F). In order to determine the moisture content of the sample stream, a thermocouple was placed within the condensation trap and the temperatures were recorded onto a strip chart recorder. The moisture of the sample stream was then determined via an equation provided by DuPont: % moisture = $0.4431 (\text{Trap Temperature, } ^\circ\text{C}) - 11.19$. The computed moisture content of the sample stream is used to convert the actual SO₂ and O₂ concentration measurements to a dry basis.

The span of the SO₂ monitoring system is 400 ppm, and the span of the O₂ monitoring system is 25% O₂. Since the monitoring system performs a zero check and automatic zero adjustment during each sampling cycle, zero gases are not used in the routine calibration procedure. After the initiation of the calibration cycle at the DuPont control unit, solenoids on the calibration gas injection lines are automatically activated during the appropriate portion of the DuPont/Thermox sampling cycle; the SO₂ and O₂ monitoring channels are calibrated concurrently.

The calibration gases are located at ground level, within the shed housing the analyzer cabinet. During calibration, a motorized three-way valve on the DuPont sampling probe opens the calibration gas injection line and closes off the sampling probe. Calibration gases travel up to the sampling probe through the calibration gas line, are injected at the sampling probe, and return to the analyzer cabinet through the heated sampling line of the monitoring system.

B.2 ENVIRONMENTAL DATA CORPORATION (EDC) MONITORING SYSTEM

The EDC DIGI 1400 Gas Emissions Monitor is an in-situ, single pass, cross-stack, flue gas monitor designed to measure concentrations of SO₂ and CO₂. The measured gas concentrations are recorded on strip charts on a real-time basis, in units of concentration. The DIGI 1400 is an ultraviolet differential absorption analyzer, operating on the principle that a specific gas absorbs ultraviolet radiation at specific wavelengths within the ultraviolet spectrum. For a particular gas, the monitor compares the absorption of ultraviolet radiation by the effluent stream at a wavelength known to be absorbed by the gas of interest to the absorption at a wavelength known to be unaffected by the gas of interest.

The monitoring system utilizes three basic components to measure the effluent stream gas concentrations. Two of the monitoring system components are mounted on opposite sides of the stack at the monitoring location. A "source" unit generates the ultraviolet radiation necessary for measurement; it is mounted directly across from an "analyzer" unit. The analyzer unit contains the necessary optical and electronic components to measure the differential absorption of ultraviolet light by the effluent at various wavelengths, and generates an output proportional to the concentrations of the gases of interest. The "display" unit can be located anywhere; this unit displays and

records the output data from the analyzer unit. The strip chart recorder for the EDC monitoring system is located in the FGD control room and the computer printer is located in the boiler control room.

B.3 CONTRAVES GOERZ MONITORING SYSTEM

The Contraves GEM-1 Emissions Monitor is an in-situ flue gas monitor designed to measure concentrations of SO_2 and CO_2 . The gas concentrations are reported on a real-time basis, in units of concentration. The GEM-1 is a non-dispersive infrared correlation spectrometer operating on the principle that a specific gas absorbs infrared radiation at specific wavelengths. Reference cells within the monitor are used to provide known reference points, so that the monitor can correlate the effluent absorption levels to specific gas concentrations.

The monitoring system utilizes three basic components to measure effluent gas concentrations. The effluent stack/duct has a "source" unit (a broadband infrared radiation generator) mounted directly across from an "analyzer" unit (an infrared radiation detector). The "display unit" can be located anywhere; this unit displays and records the output data from the analyzer unit.

B.4 LEAR SIEGLER, INC. (LSI) MONITORING SYSTEM

The LSI SM810 monitor is a limited path in-situ, dual pass, ultraviolet light, second derivative spectrophotometer. The instrument detects the curvature of the ultraviolet absorbance spectra of SO_2 and NO and converts these measurements to units of concentration (ppm). The ultraviolet light is generated in the transceiver unit and projected down a six foot probe to the optical cavity located at the end of the probe. The optical cavity is protected from particulate contamination by a ceramic thimble which allows effluent gases to diffuse into the optical cavity for measurement. A portion of the ultraviolet light is absorbed by the SO_2 and NO present in the optical cavity. The remaining light is reflected back to the transceiver, where an oscillating monochromometer is used to produce a detector output signal proportional to the curvature of the ultraviolet absorbance spectra at different points in the ultraviolet spectrum for SO_2 and NO, respectively. A converter unit conditions the transceiver output to produce signals proportional to the concentrations of SO_2 and NO in the measurement cavity.

Since the absorbance of SO_2 is temperature dependent, and since the molar concentration seen by the monitor varies with effluent temperature, a temperature sensor and electronic circuitry are incorporated in the SM810 to adjust SO_2 and NO measurements for effluent temperature variations. Also, since SO_2 exhibits narrow band absorption at the wavelengths where NO is measured, additional electronic circuitry is incorporated in the SM810 monitor to subtract the SO_2 interference from the NO measurements.

The LSI CM50 is an in-situ, electrocatalytic oxygen analyzer. When sampling combustion gases, the partial pressure of the oxygen in the sample side is lower than the partial pressure of oxygen in the reference side (which is ambient air). When the cell is kept at a temperature of about 850°C , oxygen molecules on the reference side will pick up electrons at the electrode-electrolyte interface. The porous ceramic material of ZrO_2 has the

special property of high conductivity for oxygen ions. This occurs because the metal ions form a perfect crystal lattice in the material, whereas the oxygen ions do not, resulting in vacancies. Heating the zirconium oxide causes the vacancies and oxygen ions to move about. The oxygen ions migrate to the electrode on the sample side of the cell, release electrons to the electrode, and emerge as oxygen molecules. The EMF from this process, expressed in terms of the oxygen partial pressures, is given in units of concentration ($\% O_2$).

APPENDIX C.

STRATIFICATION TESTING RESULTS

APPENDIX C.

STRATIFICATION TESTING RESULTS

It is of fundamental importance that the sampling/monitoring location be nonstratified in order to facilitate a relative accuracy evaluation of the monitoring system via single point Reference Method testing. The EPA has previously evaluated the utility of portable gas monitors for determining whether or not effluent stratification exists at installed continuous emission monitor and Reference Method sampling locations. Stratification testing for SO_2 , NO_x , O_2 , and CO_2 , as appropriate, was performed at the CEMS installation and Reference Method sampling location using an extractive monitoring system equipped with a Beckman NDIR SO_2 analyzer, a Beckman Chemiluminescence NO/NO_x analyzer, a Teledyne Micro-Fuel Cell O_2 analyzer, and a Beckman NDIR CO_2 analyzer. (A description of the extractive monitoring system is presented in Appendix E.

Performance Specification 2 (Paragraph 3.9, Appendix B, 40 CFR 60) defines stratification as: "A condition identified by a difference in excess of 10 percent between the average concentration in the duct or stack and the concentration at any point more than 1.0 meter from the duct or stack wall." Paragraph 4.3 of Performance Specification 2 provides the only guidance regarding sampling methodology to be used to determine whether stratification exists; this paragraph states: "The owner or operator may perform a traverse to characterize any stratification of effluent gases... ." Thus, a sampling location is defined as being stratified when, at any measurement point along a traverse of the duct or stack at the sampling location, the effluent concentration is greater than or less than 10 percent of the average concentration of the stack effluent. The Code of Federal Regulations do not present specific procedures to determine if effluent stratification exists at a particular monitoring location. Appendix D of this report presents the testing procedures and calculation format used to determine whether effluent stratification existed at the monitor and/or Reference Method sampling locations.

The installed monitoring system location (extractive probe for the DuPont system) and the Reference Method sampling location were positioned in the same cross-sectional area of the stack at each audited source. The DuPont/Thermox SO_2/O_2 monitor and Reference Method sampling location at Source "A" is 8.1 stack diameters downstream of the nearest flow disturbance and 11.1 stack diameters upstream of the stack outlet (see Appendix A for detailed source description). Figure C-1 shows the location of the traverse points used to perform the stratification determination; Table C-1 presents the results of the test. As is shown in Table C-1, the monitor/sampling location is nonstratified.

The EDC SO_2/CO_2 monitor and Reference Method location at Source "P" (Unit #3) is 7.7 stack diameters downstream of the nearest flow disturbance and 14.9 stack diameters upstream of the stack outlet (see Appendix A.2 for detailed source description). Stratification testing was not performed at this source due to problems with the extractive monitoring system; however, from previous experience, it is reasonable to assume that the monitor/sampling location is nonstratified.

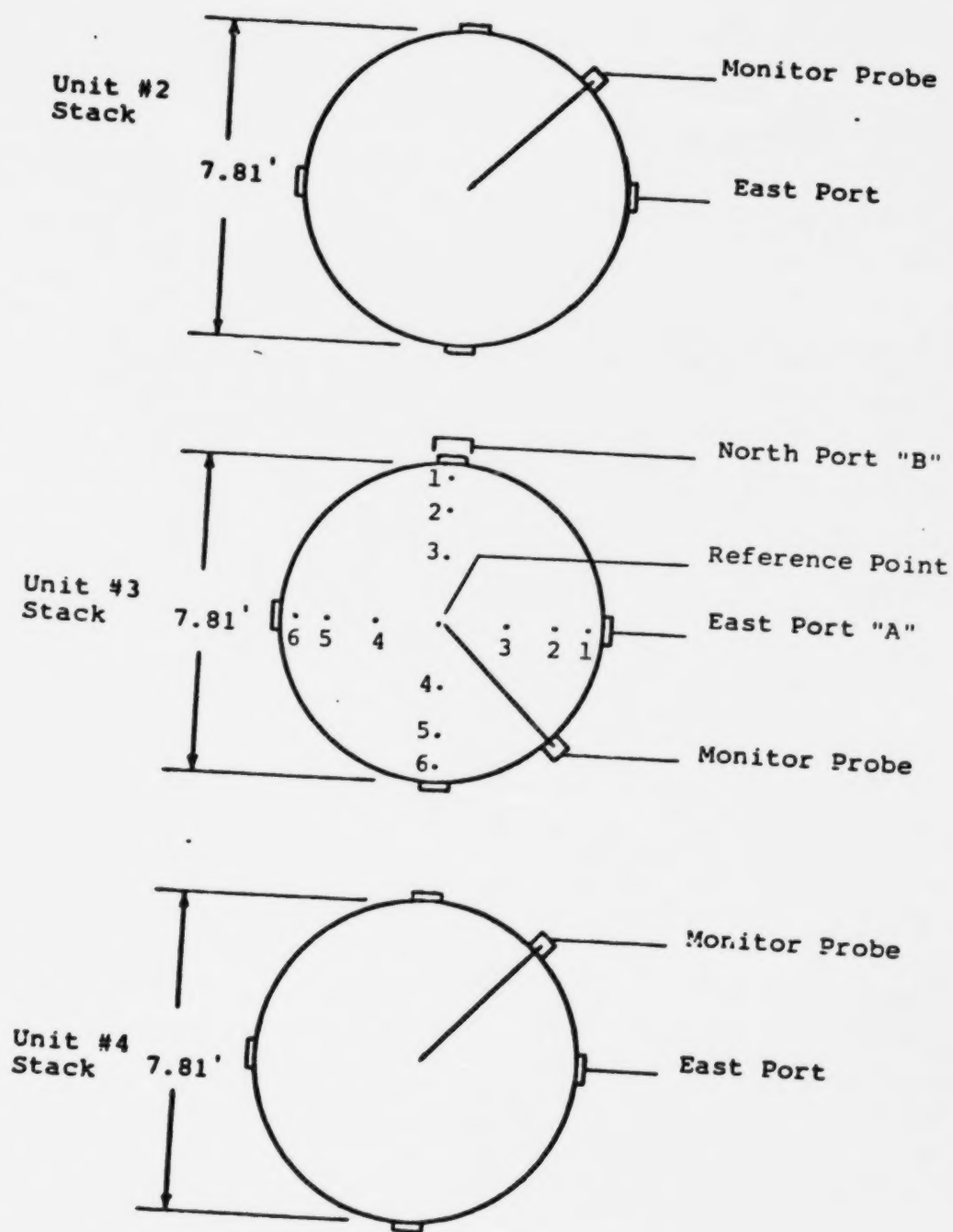


Figure C-1. Stratification Traverse Sampling Points : Source "A"

Table C-1.

STRATIFICATION TESTING RESULTS: FOR CEM AND
REFERENCE METHOD SAMPLING LOCATION

SOURCE "A": DUPONT SYSTEM

Traverse Point No.	SO ₂ Conc. (ppmd)	SO ₂ Dev. (%)	NO _x Conc. (ppmd)	NO _x Dev. (%)	O ₂ Conc. (% _D)	O ₂ Dev. (%)
1A	188	-1.0	--	--	9.7	0.0
2A	189	-0.5	--	--	9.7	0.0
3A	189	-0.5	--	--	9.6	-1.0
4A	191	0.5	--	--	9.7	0.0
5A	189	-0.5	--	--	9.6	-1.0
6A	192	1.0	--	--	9.6	-1.0
AVG	190		--	--	9.7	
1B	205	-1.9	--	--	10.2	-1.0
2B	205	-1.9	--	--	10.3	0.0
3B	210	0.5	--	--	10.2	-1.0
4B	210	0.5	--	--	10.2	-1.0
5B	210	0.5	--	--	10.3	0.0
6B	215	2.9	--	--	10.3	0.0
AVG	209		--	--	10.3	

The Contraves Goerz SO_2/CO_2 monitor and Reference Method sampling location at Source "N" (Unit #1) is 7.5² stack diameters downstream of the nearest flow disturbance and 2.5 stack diameters from the stack outlet (see Appendix A.3 for detailed source description). Figure C-2 shows the location of the traverse points used to perform the stratification determination; Table C-2 presents the results of the test. As is shown in Table C-2, the monitor/sampling location is nonstratified.

The Lear Siegler $\text{SO}_2/\text{NO}/\text{O}_2$ monitor and Reference Method sampling location at Source "S1" (Unit #1) is 8.8 stack diameters downstream of the nearest flow disturbance and 6.4 stack diameters from the stack outlet (see Appendix A.4 for detailed source description). Figure C-3 shows the location of the traverse points used to perform the stratification determination; Table C-3 presents the results of the test. As is shown in Table C-3, the monitor/sampling location is nonstratified.

The Lear Siegler $\text{SO}_2/\text{NO}/\text{O}_2$ monitor and Reference Method sampling location at Source "S2" (Unit #2) is 8.8 stack diameters downstream of the nearest flow disturbance and 6.4 stack diameters upstream of the stack outlet (see Appendix A.4 for detailed source description). Figure C-4 shows the location of the traverse points used to perform the stratification determination; Table C-4 presents the results of the test. As is shown in Table C-4, the monitor/sampling location is nonstratified.

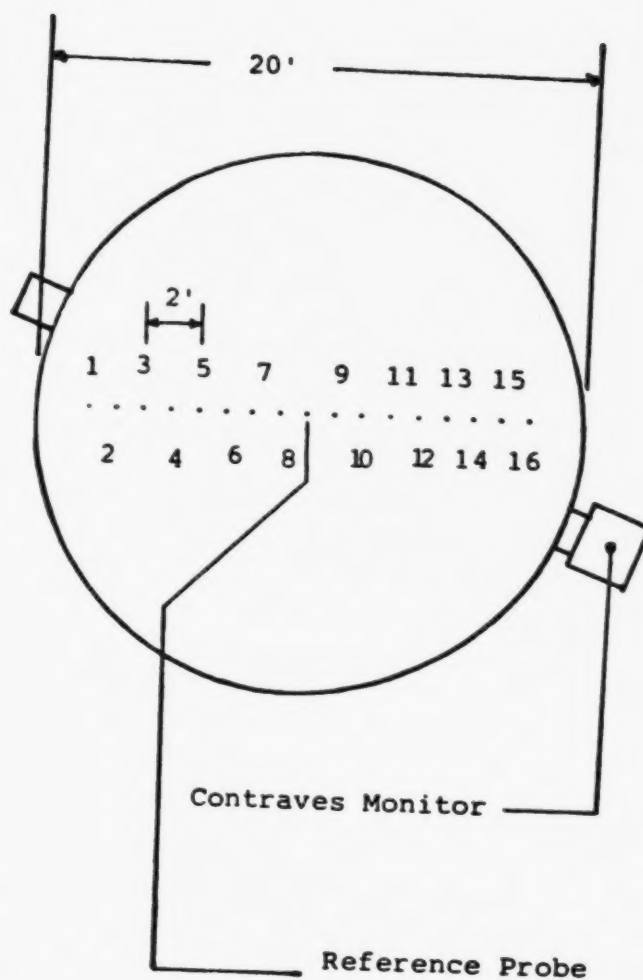


Figure C-2. Stratification Sampling Points: Source "N"

Table C-2.

STRATIFICATION TESTING RESULTS FOR CEM AND
REFERENCE METHOD SAMPLING LOCATION

SOURCE "N": CONTRAVES-GOERZ SYSTEM

Traverse Point No.	SO ₂ Conc. (ppm _d)	SO ₂ Dev. (%)	NO _x Conc. (ppm _d)	NO _x Dev. (%)	CO ₂ Conc. (% _d)	CO ₂ Dev. (%)
1	277	-1.1	--	--	10.9	-1.8
2	279	-0.4	--	--	11.3	1.8
3	273	-2.5	--	--	11.1	0.0
4	273	-2.5	--	--	11.2	0.9
5	285	1.8	--	--	11.3	1.8
6	287	2.5	--	--	11.1	0.0
7	279	-0.4	--	--	11.0	-0.9
8	278	-0.7	--	--	10.7	-3.6
9	270	-3.6	--	--	10.8	-2.7
10	281	0.4	--	--	11.1	0.0
11	278	-0.7	--	--	11.0	-0.9
12	279	-0.4	--	--	11.4	2.7
13	281	0.4	--	--	11.3	1.8
14	278	-0.7	--	--	10.9	-1.8
15	288	2.9	--	--	11.1	0.0
16	301	7.5	--	--	11.2	0.9
AVG	280		--	--	11.1	

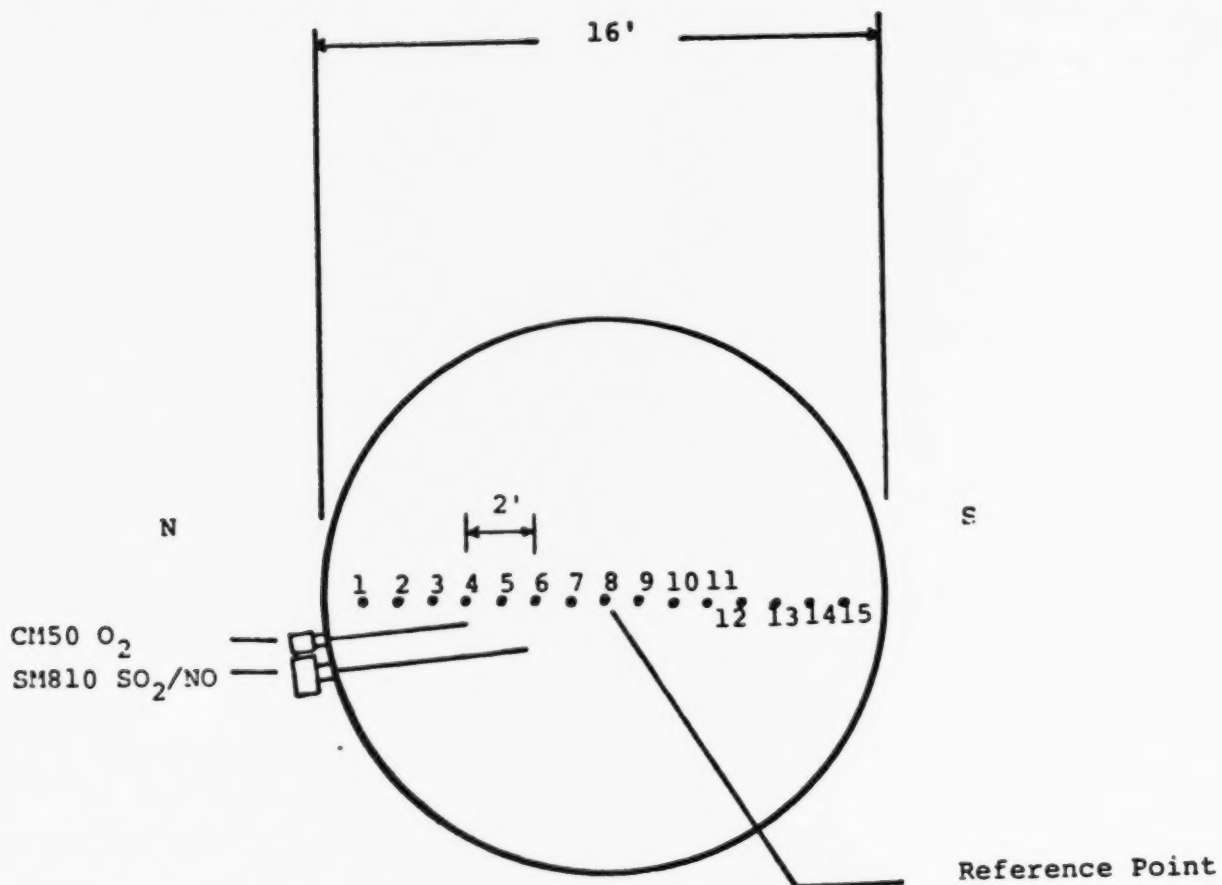


Figure C-3. Stratification Sampling Points: Source "S1"

Table C-3.

STRATIFICATION TESTING RESULTS FOR CEM AND
REFERENCE METHOD SAMPLING LOCATION

SOURCE "S1": LSI SYSTEM

Traverse Point No.	SO ₂ Conc. (ppm _d)	SO ₂ Dev. (%)	NO _x Conc. (ppm _d)	NO _x Dev. (%)	CO ₂ Conc. (% _d)	CO ₂ Dev. (%)
1	520	0.0	350	0.0	13.8	0.0
2	520	0.0	350	0.0	13.8	0.0
3	520	0.0	350	0.0	13.8	0.0
4	520	0.0	350	0.0	13.8	0.0
5	520	0.0	350	0.0	13.8	0.0
6	520	0.0	350	0.0	13.8	0.0
7	520	0.0	350	0.0	13.8	0.0
8	520	0.0	350	0.0	13.8	0.0
9	520	0.0	350	0.0	13.8	0.0
10	520	0.0	350	0.0	13.8	0.0
11	520	0.0	350	0.0	13.8	0.0
12	520	0.0	350	0.0	13.8	0.0
13	520	0.0	350	0.0	13.8	0.0
14	520	0.0	350	0.0	13.8	0.0
15	517	0.0	350	0.0	13.8	0.0
AVG	520	-0.6	350	0.0	13.8	0.0

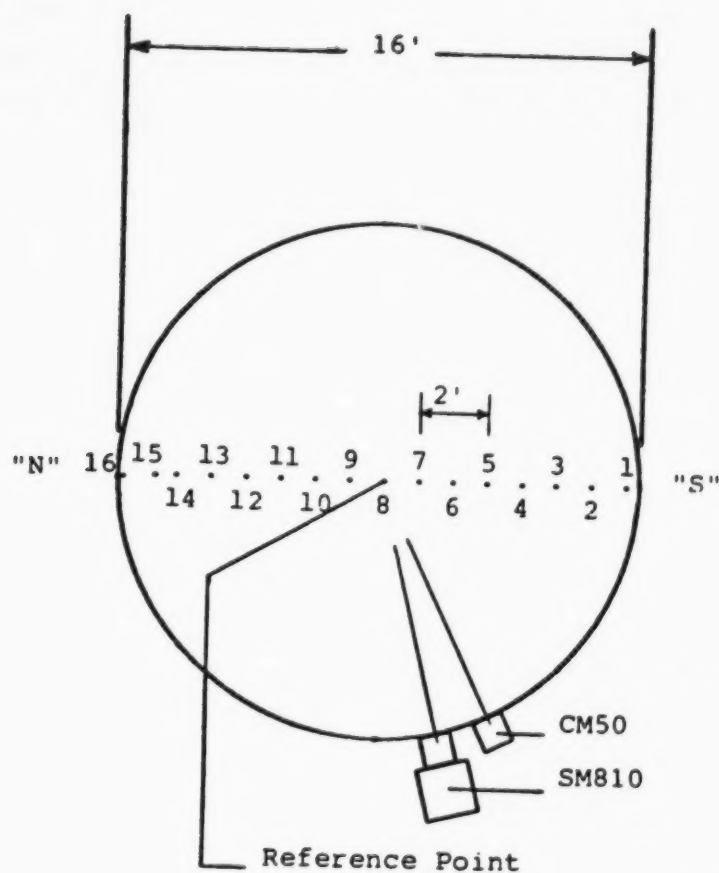


Figure C-4. Stratification Sampling Points: Source "S2"

Table C-4.

STRATIFICATION TESTING RESULTS FOR CEM AND
REFERENCE METHOD SAMPLING LOCATION

SOURCE "52": LSI SYSTEM

Traverse Point No.	SO ₂ Conc. (ppmd)	SO ₂ Dev. (%)	NO _x Conc. (ppmd)	NO _x Dev. (%)	CO ₂ Conc. (%d)	CO ₂ Dev. (%)
1	482	0.2	365	0.3	12.8	0.0
2	481	0.0	363	-0.3	12.7	-0.8
3	493	2.5	365	0.3	12.8	0.0
4	479	-0.4	364	0.0	12.8	0.0
5	479	-0.4	367	0.8	12.7	-0.8
6	480	-0.2	365	0.3	12.8	0.0
7	481	0.0	363	-0.3	12.8	0.0
8	480	-0.2	366	0.5	12.8	0.0
9	480	-0.2	362	-0.5	12.8	0.0
10	478	-0.6	364	0.0	12.8	0.0
11	479	-0.4	365	0.3	12.7	-0.8
12	482	0.2	365	0.3	12.8	0.0
13	479	-0.4	365	0.3	12.8	0.0
14	477	-0.8	362	-0.5	12.8	0.0
15	479	-0.4	363	-0.3	12.8	0.0
16	481	0.0	367	0.8	12.8	0.0
AVG	481		364		12.8	

APPENDIX D.

STRATIFICATION TESTING METHODOLOGY FOR
GASEOUS EFFLUENT CONSTITUENTS

STRATIFICATION TESTING METHODOLOGY FOR
GASEOUS EFFLUENT CONSTITUENTS

Stratification is the uneven distribution of the effluent component gases across the cross section of the ductwork or stack which transports the effluent to the atmosphere. Stratification of gaseous constituents (SO_2 , NO_x , O_2 , CO_2 , etc.) may occur at or downstream of points along the effluent pathway where the concentration of one or more constituents of the effluent changes. Thus, points at which air inleakage occurs, points at which control devices affect pollutant emission levels (such as at the outlet of flue gas desulfurization systems), and points at which dissimilar gas streams are combined, may result in stratification of the effluent stream. Samples obtained at locations where stratification exists may not provide results which are representative of the entire effluent stream. It is, in some cases, necessary to conduct a test to detect and/or quantify the existence of stratification at the existing or proposed sampling site. The procedures presented in this report are designed to determine whether effluent stratification is present; this methodology does not quantify the stratified effluent profile.

Current Performance Specifications for gaseous emission monitors require that monitors be installed in locations which provide measurements which are (or can be corrected to be) consistently representative of emissions from the source. These regulations allow the control agency to require stratification testing at proposed CEM sampling locations where the location cannot be assumed to be non-stratified.

Proposed revisions to the Performance Specifications (Jan. 26, 1981, Federal Register) allow the monitor to be installed at any location provided

that the reference method testing to determine the relative accuracy of said monitors be performed in locations that are representative of the source's emissions. Stratification testing is an accepted means of demonstrating that particular sampling locations provide representative emission measurement results.

Stratification can be measured for either pollutant gases (SO_2 or NO_x) or diluent gases (O_2 or CO_2) in units of concentration. Alternatively, at steam generators, stratification may be quantified in units of the applicable standard (lbs of pollutant per million Btu of heat input). This second alternative is useful where both the pollutant and diluent monitors are installed in such a manner as to view the same portion of the effluent, and where the potential for stratification is due only to air inleakage. Also, testing to determine the representativeness of a compliance test sampling location should be conducted in units of the standard.

The only quantitative definition for stratification which is provided in the existing regulations is contained within Paragraph 3.9, Performance Specification 2, Appendix B, 40 CFR 60. The definition is as follows:

"3.9 Stratification. A condition identified by a difference in excess of 10 percent between the average concentration in the duct or stack and the concentration at any point more than 1.0 meters from the duct or stack wall."

Paragraph 4.3 of said specification provides the only guidance regarding the sampling methodology to be used to determine whether stratification exists; this paragraph reads:

"4.3. The owner or operator may perform a traverse to characterize any stratification of effluent gases"

Thus, stratification testing is performed by making a series of traverse measurements across the stack or duct sampling location. To determine whether or not effluent stratification exists as per the above definition, the average effluent concentration across the stack or duct must also be known during each measurement made along the stack traverse. Determining the average effluent concentration concurrent with each traverse point measurement presents some difficulties. Ideally, concurrent determinations could be made by simultaneously measuring emissions at several points along the cross section of the duct or stack. However, this approach is not feasible because of the extensive manpower and equipment required to measure spatial stratification. To ensure that the stratification determination is not affected by temporal changes in the average effluent concentration, a sampling and calculation method was developed to eliminate the effects of such temporal variations. This method employs a dual probe system to sample alternately at a traverse point and a reference point.

Steady operation is preferable for stratification testing, because the results are unaffected by incremental effluent concentration shifts due to changing process conditions. If stratification testing is performed on sources operating under batch process conditions, the testing should be conducted during segments of steady operation.

EQUIPMENT DESCRIPTION

The sampling apparatus necessary for stratification testing is an extractive continuous monitoring system comprised of the following: a sample acquisition and gas conditioning system; SO_2 , CO_2 , O_2 , and/or NO_x monitors; strip chart recorders; and an automatic data processor (optional). The sample

acquisition system consists of two heated stainless steel sampling probes, and the monitoring system is capable of alternately measuring the effluent extracted through each of the two probes. A detailed description of the extractive monitoring system, along with its calibration and sampling procedures, is contained in a document prepared for the EPA, SSCD, entitled, "Transportable Continuous Emission Monitoring System Operational Protocol: Instrumental Monitoring of SO_2 , NO_x , CO_2 , and O_2 Effluent Concentrations."

SAMPLING PROCEDURE

To eliminate the effects of temporal variations of the average effluent concentration, all effluent measurements must be normalized to a specific point in time ('t') before the average concentration and percent difference at each traverse point are calculated; therefore, a dual probe system is used to measure the effluent emissions. One probe is used as a stationary reference point placed at the stack or duct centroid during the stratification sampling period; this probe is used to indicate the temporal change of the effluent concentrations. The second probe is used for sampling at specified traverse points determined in accordance with the sampling point criteria of Paragraph 3.3.1 of proposed revisions to Performance Specification 2, Appendix A, 40 CFR 60 (Federal Register, Vol. 44, No. 197, October 10, 1979). The monitoring system samples at the reference point, traverse point, reference point, etc., sequentially throughout the testing period for 3 to 5 minutes at each point. The monitoring system is calibrated with gases analyzed by the reference methods immediately before and after the stratification test.

CALCULATION PROCEDURE

The derivation of the stratification calculation procedure is based on two principle assumptions:

1. For each traverse point x , there exists a unique constant of proportionality between the concentrations of the Reference point and traverse point, such that:

$$T_x = K_x R_x \quad [\text{EQ. 1}]$$

where: T_x = Concentration at traverse point x
 K_x = Proportionality constant for point x
 R_x = Reference point concentration
 $x = 1, 2, 3, \dots$

This relationship implies that:

$$K_x = \frac{T_x}{R_x} \quad [\text{EQ. 2}]$$

2. All changes in effluent concentration occur in such a manner that the average concentration for a given measurement time interval is approximately equal to the average of the concentrations measured before and after that measurement time interval.

Thus, the average reference concentration at a time when the traverse point concentration is being measured is equal to the average of the reference concentrations measured before and after the traverse point concentration measurement.

$$R_x = \frac{R_{xab} + R_{xa}}{2} \quad [\text{EQ. 3}]$$

where: R_{xb} = Reference concentration before measurement of traverse point x

R_{xa} = Reference concentration after measurement of traverse point x

In order to compare one traverse point measurement to another on a consistent basis, the effect of effluent concentration changes with time must be eliminated. Consequently, all traverse point measurements must be normalized to some benchmark reference time, t .

$$T_{xn} = K_x R_t \quad [\text{EQ. 4}]$$

T_{xn} = normalized value of concentration for point x

K_x = proportionality constant, defined in EQ. 2

R_x = Reference concentration at reference time, t

Equation 4 results in the value that would have been measured for traverse point x if the reference concentration had been equal to R_t .

Combining EQ. 2 and EQ. 4 and simplifying the resultant normalized concentration is:

$$T_{xn} = \frac{T_x}{R_x} R_t$$

Changes in effluent flow rate or other process operating parameters, such as failure of a fan, could cause changes in the nature of any stratification present. This could cause the K_x values to change, rendering normalized traverse concentration inaccurate. Again, this is only a problem if stratification does exist, and the test will still detect this stratification, although it will not accurately quantify it.

The second assumption may provide a more likely reason for inaccurate indications of the magnitude of effluent stratification. This assumption is valid only if the sampling time for each traverse point is small compared to any cyclic changes in the effluent concentrations, or if the magnitude of these changes in concentration is small. As changes in concentration become larger, the assumption that:

$$R_x = \frac{R_{xb} + R_{xa}}{2}$$

becomes more critical. Errors in this assumption become more pronounced as the measurement time period approaches one-half the time period of a cyclic concentration change. The most likely result of such errors is an overestimation of stratification. Thus, the previously discussed stratification test procedure will err conservatively, and indications of no stratification can be viewed with a high level of confidence.

Source and Location

[illegible]

APPENDIX E.

EXTRACTIVE MONITORING SYSTEM DESCRIPTION

APPENDIX E.

EXTRACTIVE MONITORING SYSTEM DESCRIPTION

E.1 GENERAL DESCRIPTION

The transportable extractive monitoring system configuration allows the use of either one or two sampling probes. Two sampling probes are utilized during stratification tests, in order to provide consecutive effluent concentration measurements both at a reference point and at a number of traverse points. A single sampling probe is utilized to provide effluent concentration measurements during the relative accuracy tests. The extractive monitoring system sampling probes are constructed of 3/8 inch diameter stainless steel tubing, and are heated to prevent the condensation of effluent moisture. The sampling probes are also equipped with a coarse in-stack filter for the removal of the particulate matter.

The extractive monitor sample stream is conveyed from the sampling probes to the sample conditioning system through 3/8 inch diameter, Teflon, heated sampling lines approximately 25 feet long. The conditioning system consists of a heated environmental chamber which encloses a fine particulate filter and a Perma Pure dryer for the removal of moisture from the sample stream. The conditioning system is equipped with the necessary valves and fittings to allow the injection of calibration gases into the inlet of the conditioning system.

The dried, filtered sample stream leaving the conditioning system is transported to the analyzers via 3/8 inch diameter Teflon lines and a sample pump located upstream of the analyzer inlets. A sample manifold board containing flow meters, flow control valves, and auxiliary calibration gas injection ports is located at the analyzer inlets.

E.2 BECKMAN MODEL 951 NO/NO_x CHEMILUMINESCENCE ANALYZER

The Beckman Model 951 NO/NO_x chemiluminescence analyzer automatically and continuously analyzes a flowing gas sample, performing the desired analysis of either nitric oxide (NO) or oxides of nitrogen (NO_x).

In the determination of NO, the sample is converted quantitatively to NO₂ by gas phase oxidation with molecular ozone produced within the analyzer. In this reaction, the NO₂ molecules are elevated to an electronically excited state, and then immediately reverted to a non-excited ground state. The reversion is accompanied by emissions of photons, which impinge on a photomultiplier detector and generate a low level DC current. The current then is amplified and used to drive a front panel meter and a data recorder.

The NO_x mode employs the same measurement principles as the NO mode described above, with the exception that before entry into the reaction chamber, the sample is routed through a converter, where NO₂ is reduced to form NO. Thus, the NO_x concentration seen by the instrument includes both the contribution of the NO in the effluent and the NO resulting from the reduction of NO₂.

The analyzer is equipped with seven ranges: 10, 25, 100, 250, 1000, 2500, and 10,000 ppm NO or NO_x full scale. Operation of the analyzer requires delivery of the sample stream at 4-6 psig to the analyzer inlet, and the use of an auxiliary compressed air supply for the internal ozone generator.

E.3 BECKMAN MODEL 865 NDIR SO₂ MONITOR

The Model 865 Infrared Analyzer automatically and continuously determines the concentration of SO₂ in a flowing gas mixture. The analytical technique is based on the absorption of infrared energy by SO₂. Within the analyzer, two equal energy infrared beams are directed through two optical cells: a flow-through sample cell and a sealed reference cell. Solid state electronic circuitry continuously measures the difference between the amounts of infrared energy absorbed in the two cells. The concentration is read out on a front panel meter, which has a scale of 0-100% of the measurement range. A field-selectable current output (4-20 or 10-50 ma) is provided for a data recorder hook-up.

Since the output of the Beckman 865 analyzer is inherently non-linear, an optional linearizer circuit board is employed to provide a linear output proportional to the concentration of SO₂ in the sample gases. A solenoid activated reflecting window is provided to facilitate routine upscale calibration of the monitoring system. This window reflects a fixed amount of infrared energy from the sample beam, simulating a specified concentration of SO₂. The instrument is equipped with two ranges: Range 1, which is adjustable (from 500 to 2500 ppm SO₂ fullscale); and Range 3, which is equal to 20% of Range 1. (Range 2 is omitted from this instrument.)

E.4 TELEDYNE MODEL 320P-4 O₂ MONITOR

The Teledyne Model 320P-4 O₂ Monitor utilizes a patented micro-fuel cell which consumes oxygen from the atmosphere surrounding the measuring probe. The analyzer generates an electrical current proportional to the amount of O₂ consumed. The generated current is then amplified and used to drive a front panel meter. An auxiliary output of 0-100 mv. D. C. is supplied to drive a recorder. The analyzer is equipped with three selectable ranges of 0-5%, 0-10% and 0-25% O₂.

E.5 BECKMAN MODEL 864 NDIR CO₂ MONITOR

The Beckman Model 864 Infrared Analyzer automatically and continuously determines the concentration of CO₂ in a flowing gas mixture. The analytical technique is based on the absorption of infrared energy by CO₂. Within the analyzer, two equal energy infrared beams are directed through two optical cells: a flow-through sample cell and a sealed reference cell. Solid state electronic circuitry continuously measures the difference between the amounts of infrared absorbed in the two cells. The concentration is read out on a front panel meter, which has a scale of 0-100% of the measurement range. A field selectable current output (4-20 or 10-50 ma) is provided for a data recorder hook-up.

Since the output of the Beckman 864 analyzer is inherently non-linear, an optional linearizer circuit board is employed to provide a linear output proportional to the concentration of CO_2 in the sample gases. A solenoid activated reflecting window is provided to facilitate routine upscale calibration of the monitoring system. This window reflects a fixed amount of infrared energy from the sample beam, simulating a specified concentration of CO_2 . The instrument is equipped with two ranges: Range 1, which is adjustable (from 5% to 20% CO_2 fullscale); and Range 3, which is equal to 20% of Range 1. (Range 2 is omitted from this instrument.)

E.6 EXTRACTIVE MONITORING SYSTEM OPERATION

A transportable extractive monitoring system was employed in the stratification test. Prior to the stratification test, all of the monitoring system components were assembled as previously described. The analyzers were allowed to complete a warm-up period, and were then setup and calibrated according to the manufacturers' written instructions. The analyzers then were calibrated by injecting calibration gases at the sample manifold board. Finally, the analyzers again were calibrated by injecting calibration gases upstream of the conditioning system.

During the stratification test, two sampling probes were utilized to provide effluent NO , SO_2 , O_2 , and CO_2 concentration measurements at a reference sampling point and at a series of traverse points. The sampling system was switched between the traverse and reference sampling probes, in order to provide control measurements between each of the points sampled across the stack diameter.

APPENDIX F.

CORRESPONDENCE FROM CONTRAVES-GOERZ TO EPA (9/8/82)

September 8, 1982

United States EPA
Mail Drop 46
Quality Assurance Division
Research Triangle Park, NC 27711

Attention: Roosevelt Rollins

Subject: History of Contraves Stack Monitor (Serial No. 127601)
SO₂, CO₂ at CIPSCO

Gentlemen:

As a follow-up to our recent meeting, I am writing to summarize some history of the Contraves Stack SO₂/CO₂ Monitor (Serial No. 127601) at CIPSCO.

The unit, initially purchased by CIPSCO from ERT (Environmental Research Technology) in 1977, was sent to Contraves in 1979 for retrofitting of an improved CO₂ bandpass filter and for correction of a number of mechanical and electrical problems with the original ERT design. The instrument was then re-calibrated to 0-4000 ppm SO₂ and 0-20% CO₂, and was re-installed in late 1979.

The unit ran well, considering that it was being used to measure 200-300 ppm of SO₂ (on a scrubber stack) out of a full scale calibration of 4000 ppm. This required a relative accuracy some four times better than would have been required had the instrument been calibrated for a more reasonable range such as 0-1000 ppm.

During 1979 and 1980 the unit passed several relative accuracy tests. In November of 1980, Contraves implemented its audit cell procedure (the precursor to our current Quality Assurance Procedures TR 5389) and passed the SO₂ calibration error test at that time. The cells used corresponded to 1952 ppm and 2588 ppm, which were appropriate for the 0-4000 ppm calibration.

Meanwhile, during 1979, 1980, Contraves introduced a number of additional improvements into its current production line of M100's. These included improvements in cells, detectors, pc layout and environmental temperature control.

CGC Division of Contraves Goerz Corporation

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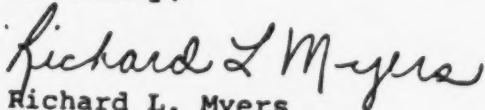
In late October of 1981, Contraves made its first service call to CIPSCO in nearly a year. Using an audit cell, the serviceman diagnosed and replaced a cracked coorelation cell and a misadjusted gain pot. Several suspect optical components were also replaced. In a follow-up visit in November, the unit was restored to normal operation, although there remained the possibility that the instrument was misadjusted due to the number of replaced components.

Our next call for service came in late August of 1982. This time we discovered a bad detector, an overheating environmental chamber, and a defective (-15 volt) supply which was supplying bad reference voltages. The instrument had been clearly failing its daily precision check for a long time. It is now my understanding that RTP-initiated relative accuracy tests indicated out-of-tolerance readings throughout 1982. This is consistent with our after-the-fact findings.

Based on this experience, we recommend that: (1) future tests be run on a current (i.e., post-1979) model of the Contraves M100, (2) that the unit in question be calibrated to a full-scale range no greater than 3-4 times the typical reading and no greater than twice the applicable standard, (3) that a quarterly program be instituted whereby Contraves' Quality Assurance procedures be run independently but within five days of an EPA-sponsored relative accuracy test. We can demonstrate that our state-of-the-art monitor can be maintained and the quality of the data reliably assessed, using our audit cells and related procedures.

Unfortunately, recent experiences at CIPSCO have not permitted completely meaningful assessment of the Contraves monitor. We would like very much to participate in a program that will.

Sincerely,



Richard L. Myers
Manager, Operations

RLM:jas

cc: L. C. Mackey
CIPSCO File
Fld. Serv. File
T. Logan, EPA